Vol. III | OCTOBER, 1928. | Parts III & IV

THE PROBLEM OF ALIEN IMMIGRATION INTO GREAT BRITAIN, ILLUSTRATED BY AN EXAMINATION OF RUSSIAN AND POLISH JEWISH CHILDREN.

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PART III (*cont.*).

CONTENTS.

F. *On the Relation of Ocular Characters to Cephalic and Pigmentation Characters.* The characters we propose to deal with here are (*a*) the three Cephalic Indices, namely $I_1 = 100$ (Maximum parietal Breadth)/(Glabellar occipital Length), $I_2 = 100$ (Auricular Height)/(Glabellar occipital Length) and $I_3 = 100$ (Auricular Height)/(Maximum parietal Breadth), (*b*) the Interpupillary Index, being 100 (distance between centres of pupils)/(Maximum parietal Breadth), (*c*) the Index of the Sunken Eye (see Vol. II, p. 118), and (*d*) the Hair and Eye (Iris) Colours as registered by Fischer and Martin's scales. We will take our ocular characters in the order adopted in Section C.

(*a*) *Visual Acuity.* We can deal either with Monocular or Binocular Vision, and either with the Special or the Medical Examination, but we shall confine our attention to the Special Examination as we believe it to be the more accurate.

(i *a*) *Visual Acuity and Eye Colour.* Table CCCXLIII provides the data for Monocular Vision.

Table CCCXLIII. *Visual Acuity (Monocular) and Eye Colour.*

Eye Colour: Martin's Scale	Visual Acuity: 1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Dark Brown (2, 3)	—	1	4	16	23	8	3	11	1	1	—	—	68
Medium Brown (4)	—	8	21	63	64	32	30	24	21	9	7	3	282
Light Brown (5, 6)	1	2	14	43	42	16	23	19	9	6	6	5	186
Hazel (7, 8)	2	3	21	32	31	33	22	17	2	13	2	4	182
Grey (9–12)	—	—	15	20	44	16	17	10	9	15	3	3	152
Blue Grey (13, 14)	—	3	9	17	28	7	13	12	7	4	—	—	100
Pure Blue (15, 16)	—	—	1	6	8	5	6	8	1	1	—	2	38
Totals	3	17	85	197	240	117	114	101	50	49	18	17	1008

The following are the array-means:

Grade of Eye Pigmentation

Martin's Scale	Normal Scale	Mean Visual Acuity
Dark Brown (2, 3)	1·9345	·8449 ± ·0293
Medium Brown (4)	·8537	·7941 ± ·0144
Light Brown (5, 6)	·1537	·7766 ± ·0174
Hazel (7, 8)	− ·3138	·7937 ± ·0179
Grey[1] (9–12)	− ·8078	·7359 ± ·0196
Blue Grey (13, 14)	−1·3820	·7970 ± ·0242
Pure Blue (15, 16)	−2·1782	·6813 ± ·0392
General Population[2]	Origin	·7815 ± ·0076

[1] I.e. 9, 10 = Hazel Greys, and 11, 12 = Grey Blues. [2] Standard Deviation ·3586.

With the exception of the Pure Blues and possibly of the more intense Dark Browns, it cannot be said that the mean visual acuities of any shade of eye colour differ definitely from the population mean. But an examination of the lower half of Diagram 151 indicates that there is on the whole a slight drop in visual acuity as we pass from the darkest to the lightest eyes. If we assume a normal distribution for eye pigmentation, we find for the correlation coefficient:

$$r = \cdot 0634 \pm \cdot 0211,$$

which is probably, if small, just significant. We have again for the correlation ratio of visual acuity on eye colour:

$$\eta'^2_{VA.EC} = \cdot 008{,}268,$$

$$\bar{\eta}^2_{VA.EC} = \cdot 005{,}952 \pm \cdot 002{,}311,$$

showing that $\eta'^2_{VA.EC}$ hardly differs significantly from $\bar{\eta}^2_{VA.EC}$. If, notwithstanding, we proceed to correct for class-index* we find

$$\eta'_{VA.EC} = \cdot 0935\ [\pm \cdot 0211],$$

against $\bar{\eta}_{VA.EC} = \cdot 0771$.

The difference between r and $\eta'_{VA.EC}$ and the slender basis for both do not justify the use of anything but a straight line for graduation.

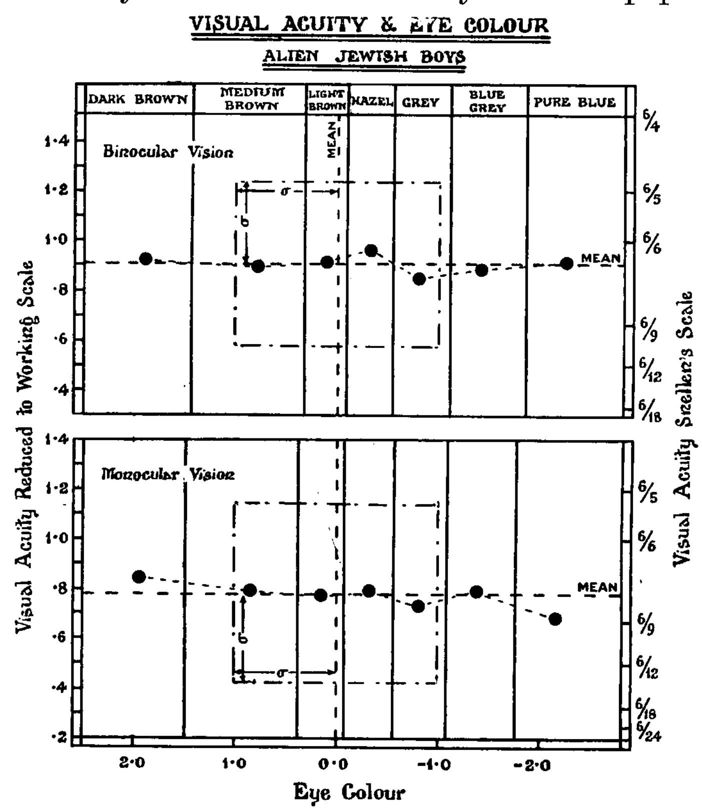

Diagram 151.

(i *b*) *Visual Acuity* (*Binocular*) *and Eye Colour.* Since the two eyes are of unequal visual acuity we should expect the association to be lessened. The following table contains our data:

Table CCCXLIV. *Visual Acuity* (*Binocular*) *and Eye Colour.*

Visual Acuity

Eye Colour: Martin's Scale	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Dark Brown (2, 3)	—	—	4	8	13	3	3	2	—	—	—	—	33
Medium Brown (4)	—	5	16	43	28	11	8	9	6	3	3	1	133
Light Brown (5, 6)	1	—	13	21	13	7	11	2	1	2	2	—	73
Hazel (7, 8)	1	—	16	19	18	11	6	2	1	—	—	1	75
Grey (9–12)	—	1	10	18	16	7	5	5	2	4	1	1	70
Blue Grey (13, 14)	1	1	4	14	11	2	6	5	1	1	—	—	46
Pure Blue (15, 16)	—	—	1	4	7	—	—	2	—	—	—	—	14
Totals	3	7	64	127	106	41	39	27	11	10	6	3	444

* Class-index correlation for Eye Colour treated as a normal distribution = ·9722.

The array-means of Visual Acuity for each Eye Colour are:

Grade of Eye Pigmentation

Martin's Scale	Normal Scale	Mean Visual Acuity
Dark Brown (2, 3)	1·9033	·9273 ± ·0383
Medium Brown (4)	·7958	·8968 ± ·0191
Light Brown (5, 6)	·1111	·9106 ± ·0258
Hazel (7, 8)	− ·3185	·9649 ± ·0254
Grey (9–12)	− ·7994	·8574 ± ·0263
Blue Grey (13, 14)	−1·4127	·8876 ± ·0325
Pure Blue (15, 16)	−2·2487	·9171 ± ·0589
General Population[1]	Origin	·9063 ± ·0105

[1] Standard Deviation ·3265.

None of these means with the just possible exception of the hazel eyes shows any significant difference from that of the general population. This is confirmed by the correlation ratio

$$\eta'^2_{VA.EC} = \cdot 009{,}933, \qquad \bar{\eta}^2_{VA.EC} = \cdot 013{,}513 \pm \cdot 005{,}221,$$

while the product moment correlation is given by

$$r = \cdot 0210 \pm \cdot 0320,$$

again marking no significant association. The upper half of Diagram 151 confirms this result graphically. We conclude that there is very little relation indeed between Visual Acuity and Eye Colour within a race. It is probably just sensible for monocular vision, but we cannot detect it for binocular vision.

(ii *a*) *Visual Acuity and Hair Colour.* As in the case of Eye Colour, we deal first with Monocular Vision, for which the data are given in Table CCCXLV.

Table CCCXLV. *Visual Acuity* (*Monocular*) *and Hair Colour.*

Visual Acuity

Fischer's Scale (Hair)	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Black (27, 28)	—	—	4	7	11	6	1	3	2	2	—	2	38
Very Dark Brown (4) ...	—	2·5	17	42	58	26	16·5	18	10	13	3	3	209
Dark Brown (5, 30) ...	1	4·5	22	56	50	23	44·5	28	22	13	8	3	275
Medium Brown (6, 7) ...	2	3	24	67	64	42	30	34	10	15	7	6	304
Light Brown (8–11, 13, 14)	—	7	14	21	42	19	17	15	3	6	—	—	144
Slatey (25, 26)	—	—	3	3	10	—	—	3	1	—	—	2	22
Red (1, 2, 3)	—	—	1	1	5	1	4	—	2	1	—	1	16
Totals	3	17	85	197	240	117	113	101	50	50	18	17	1008

The array-means for given Hair Colour are:

Grade of Hair Colour	Mean Visual Acuity
Black	·7892 ± ·0393
Very Dark Brown...	·7906 ± ·0168
Dark Brown ...	·7467 ± ·0146
Medium Brown ...	·7817 ± ·0139
Light Brown ...	·8378 ± ·0202
Slatey	·8064 ± ·0516
Red	·6688 ± ·0606
General Population[1]	·7811 ± ·0076

[1] Standard Deviation ·3591.

It may be doubted whether any of these means can be considered significantly different from the population value, having regard to their probable errors. This is confirmed by the lower half of Diagram 152, and the following values of the constants:

$$\eta'^2_{VA.HC} = \cdot 007{,}880, \qquad \bar{\eta}^2_{VA.HC} = \cdot 005{,}952 \pm \cdot 002{,}311.$$

$\eta'^2_{VA.HC}$ is thus not significant having regard to $\bar{\eta}^2_{VA.HC}$*.

* Corrected for class-index, $\eta_{VA.HC} = \cdot 0918$ ($\bar{\eta}_{VA.HC} = \cdot 0771$).

Assuming a normal scale for hair pigmentation—not very legitimate with Red at the end of the scale—we have

$$r = -\cdot 0201 \pm \cdot 0212.$$

It is fairly clear that no other position of Red would essentially modify this result.

We conclude that hair pigmentation has little to do with visual acuity, even the red-haired boys with their low mean acuity may be a result of sampling on the small number of 16.

(ii *b*) *Visual Acuity* (*Binocular*) *and Hair Colour.* The results of this investigation confirm those for monocular vision. The red-haired boys have a low visual acuity as in the previous case; the slatey-haired boys appear to have a high visual acuity, but this difference from the previous result arises from the fact that of two boys in this class (see Table CCCXLV) one had a very poor right eye (·04) and the other a very poor left (·04), but the vision being good in the other eye of each, they do not influence in the same way the means in the case of binocular vision.

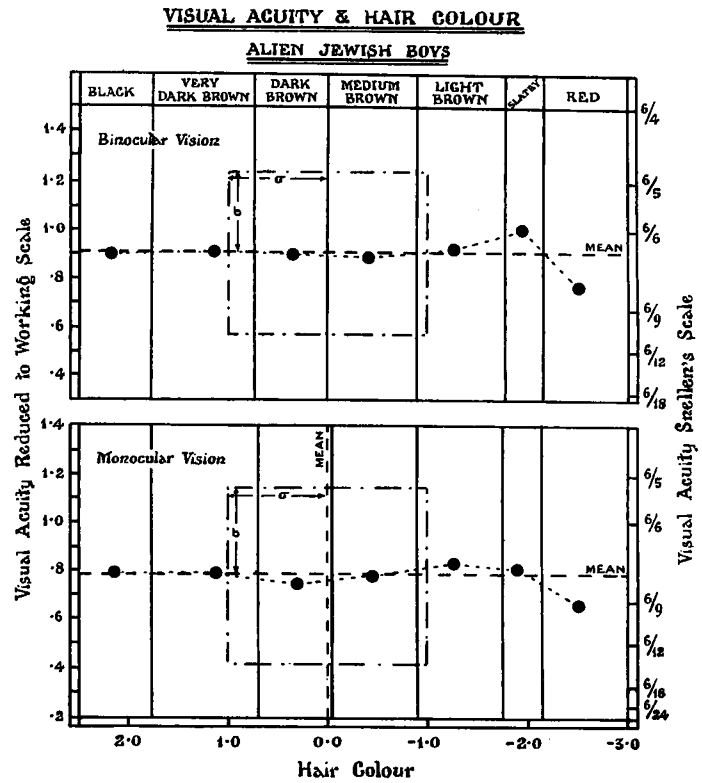

Diagram 152.

Table CCCXLVI. *Visual Acuity* (*Binocular*) *and Hair Colour.*

Hair Colour[1]	Visual Acuity 1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Black	—	—	3	5	3	3	1	—	1	—	—	1	17
Very Dark Brown	1	—	14	24	22·5	6	7	4	4	2	1	—	85·5
Dark Brown ...	1	1	20	35	22·5	14	8	9	3	3	2	1	119·5
Medium Brown ...	1	3	18	40	35	12	14	8	2	5	3	1	142
Light Brown ...	—	3	8	15	20	6	6	5	1	—	—	—	64
Slatey	—	—	1	5	2	—	—	1	—	—	—	—	9
Red	—	—	—	3	1	—	2	—	—	—	—	1	7
Totals	3	7	64	127	106	41	38	27	11	10	6	4	444

[1] See preceding table for the numbers of Fischer's scale.

Diagram 152 shows how little relation visual acuity within the race has to hair colour. The array-means with their probable errors are given below.

Grade of Hair Colour	Mean Visual Acuity
Black	·8982 ± ·0538
Very Dark Brown...	·9132 ± ·0240
Dark Brown ...	·9026 ± ·0203
Medium Brown ...	·8918 ± ·0186
Light Brown ...	·9289 ± ·0277
Slatey	1·0033 ± ·0739
Red	·7771 ± ·0838
General Population[1]	·9051 ± ·0105

[1] Standard Deviation of Visual Acuity ·3287.

Not one of these array-means marks a significant differentiation of visual acuity with pigmentation. The same result is reached from the correlation constants:

$$\eta'^2_{VA.HC} = \cdot 003{,}729, \qquad \bar{\eta}^2_{VA.HC} = \cdot 013{,}513 \pm \cdot 005{,}221,$$

and the product moment coefficient based on a normal scale for hair pigment:

$$r = - \cdot 0160 \pm \cdot 0320.$$

Although we are thus compelled to suppose that intra-racially there is no association of pigmentation with visual acuity it does not follow that inter-racially such may not exist.

We now pass to such measurements as we have of the shape of the head. In the first place we have to deal with the three cephalic indices $100\,B/L$, $100\,H/L$ and $100\,H/B$. We start with $I_1 = 100\,B/L$, the usual cephalic index.

(iii *a* and *b*) *Visual Acuity and Cephalic Index*, $I_1 = 100\,B/L$. The following tables give the data for monocular and binocular vision:

Tables CCCXLVII and CCCXLVIII. *Visual Acuity (Monocular and Binocular) with* $I_1 = 100\,B/L$.

Central Values	Monocular Vision												Totals
	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	
69·95	—	—	—	—	—	2	1	3	—	—	—	—	6
71·95	—	—	—	—	—	—	—	1	—	1	—	—	2
73·95	—	—	—	2	5	1	—	—	—	—	—	—	8
75·95	—	—	—	9	12	4	3	—	1	1	2	—	32
77·95	—	2	4	22	33	11	13	9	4	5	—	1	104
79·95	—	5	24	33	29	24	19	17	6	11	6	6	180
81·95	—	1	7	35	55	28	25	20	13	6	2	4	196
83·95	3	3	20	43	54	30	26	23	14	11	4	3	234
85·95	—	3	20	39	28	11	14	19	5	13	3	1	156
87·95	—	1	6	10	17	3	9	5	3	—	—	2	56
89·95	—	—	3	3	8	2	2	2	2	2	1	1	26
91·95	—	2	1	1	3	—	1	1	1	—	—	—	10
Totals	3	17	85	197	244	116	113	100	49	50	18	18	1010

Central Values	Binocular Vision												Totals
	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	
69·95	—	—	—	—	—	1	—	1	—	—	—	—	2
71·95	—	—	—	—	—	—	—	1	—	—	—	—	1
73·95	—	—	—	2	2	—	—	—	—	—	—	—	4
75·95	—	1	2	3	7	2	—	—	—	1	—	—	16
77·95	—	—	5	14	17	—	6	1	2	1	—	—	46
79·95	1	1	15	17	20	7	6	4	2	3	4	1	81
81·95	—	2	3	31	19	10	5	6	3	2	—	1	82
83·95	2	1	17	30	17	11	9	6	2	1	1	—	97
85·95	—	2	14	21	16	4	5	5	1	2	1	1	72
87·95	—	—	5	5	6	4	4	1	—	—	—	1	26
89·95	—	—	2	4	1	1	2	2	1	—	—	—	13
91·95	—	—	1	—	1	1	1	—	—	—	—	—	4
Totals	3	7	64	127	106	41	38	27	11	10	6	4	444

Array-Means

Grade of Cephalic Index, 100 B/L	Mean Visual Acuity Monocular	Grade of Cephalic Index, 100 B/L	Mean Visual Acuity Binocular
74·70	·7796 ± ·0349	74·91	·9065 ± ·0462
77·95	·8007 ± ·0237	77·95	·9120 ± ·0327
79·95	·7781 ± ·0180	79·95	·8742 ± ·0246
81·95	·7482 ± ·0173	81·95	·8788 ± ·0245
83·95	·7818 ± ·0158	83·95	·9434 ± ·0225
85·95	·8046 ± ·0194	85·95	·9324 ± ·0261
87·95	·8189 ± ·0323	87·95	·8919 ± ·0435
90·51	·7753 ± ·0403	90·42	·8447 ± ·0538
General Population[1]:	·7818 ± ·0076	General Population[1]:	·9051 ± ·0105

[1] Standard Deviations: Monocular Vision ·3589, Binocular Vision ·3287.

The remaining constants are:

Cephalic Index, I_1, Mean: Monocular 82·56, Binocular 82·57.

„ „ Standard Deviation: „ 3·5204, „ 3·5738.

Product Moment Coefficient r: Monocular $\cdot 0253 \pm \cdot 0212$, Binocular $\cdot 0265 \pm \cdot 0320$.

Correlation Ratio: Monocular $\eta'^2_{VA.I_1} = \cdot 003{,}236$, $\bar{\eta}^2_{VA.I_1} = \cdot 006{,}931 \pm \cdot 002{,}487$.

„ „ Binocular $\eta'^2_{VA.I_1} = \cdot 008{,}310$, $\bar{\eta}^2_{VA.I_1} = \cdot 015{,}766 \pm \cdot 005{,}640$.

Whether we judge by the correlation ratios, the coefficients of correlation or array-means, we

find no significant differentiation of visual acuity with cephalic index 100 B/L. It seems unnecessary to provide graphs for what is here obvious on the constants.

(iv *a* and *b*) *Visual Acuity and Cephalic Index,* $I_2 = 100\ H/L$.

Tables CCCXLIX and CCCL. *Visual Acuity* (*Monocular and Binocular*) *with* $I_2 = 100\ H/L$.

Central Values	Monocular Vision												Totals
	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	
59·95	—	—	—	2	—	—	—	—	—	—	—	—	2
61·95	—	—	—	—	—	2	—	—	—	—	—	—	2
63·95	—	—	—	—	6	3	2	3	—	—	—	—	14
65·95	—	—	4	11	4	1	5	7	3	—	—	1	36
67·95	—	—	4	22	32	15	11	11	4	9	4	2	114
69·95	—	2	23	51	45	27	32	24	7	16	3	6	236
71·95	2	8	31	60	59	25	25	12	10	7	6	3	248
73·95	1	3	17	34	46	26	23	31	6	9	4	2	202
75·95	—	4	2	11	24	11	9	7	12	8	1	3	92
77·95	—	—	4	6	26	6	3	4	5	—	—	—	54
79·95	—	—	—	—	1	—	2	1	2	—	—	—	6
81·95	—	—	—	—	—	—	—	—	—	—	—	—	—
83·95	—	—	—	—	—	—	—	—	—	1	—	1	2
Totals	3	17	85	197	243	116	112	100	49	50	18	18	1008

Central Values	Binocular Vision												Totals
	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	
59·95	—	—	—	1	—	—	—	—	—	—	—	—	1
61·95	—	—	—	—	—	1	—	—	—	—	—	—	1
63·95	—	—	1	2	1	—	1	—	—	—	—	—	5
65·95	—	—	4	4	3	—	1	2	—	—	—	—	14
67·95	—	—	6	15	13	4	1	5	1	3	2	—	50
69·95	—	—	14	35	23	11	13	8	—	2	1	—	107
71·95	2	4	22	37	24	7	8	3	3	2	2	1	115
73·95	1	1	11	21	25	8	8	6	3	2	1	1	88
75·95	—	2	3	9	9	4	3	2	3	1	—	2	38
77·95	—	—	3	3	8	4	2	—	1	—	—	—	21
79·95	—	—	—	—	—	1	1	1	—	—	—	—	3
81·95	—	—	—	—	—	—	—	—	—	—	—	—	—
83·95	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	3	7	64	127	106	40	38	27	11	10	6	4	443

From these tables we deduce the following values:

Array-Means

Grade of Cephalic Index, 100 H/L	Mean Visual Acuity Monocular	Grade of Cephalic Index, 100 H/L	Mean Visual Acuity Binocular
65·06	·7730 ± ·0330	65·00	·9767 ± ·0484
67·95	·7286 ± ·0227	67·95	·8496 ± ·0308
69·95	·7720 ± ·0158	69·95	·9061 ± ·0215
71·95	·8720 ± ·0154	71·95	·9750 ± ·0207
73·95	·7658 ± ·0170	73·95	·8768 ± ·0237
75·95	·6805 ± ·0253	75·95	·8237 ± ·0360
78·34	·7673 ± ·0308	78·20	·8579 ± ·0453
General Population[1]:	·7819 ± ·0076	General Population[1]:	·9054 ± ·0105

[1] Standard Deviations: Monocular Vision ·3592, Binocular Vision ·3290.

Cephalic Index, I_2, Mean: Monocular 71·82, Binocular 71·76.

" " Standard Deviation: " 3·1482, " 3·0203.

Product Moment Coefficient r: Monocular $-$ ·0271 ± ·0212, Binocular $-$ ·0587 ± ·0320.

Correlation Ratio: Monocular $\eta'^2_{VA.I_2}$ = ·025,945, $\bar{\eta}^2_{VA.I_2}$ = ·005,952 ± ·002,311.

" " Binocular $\eta'^2_{VA.I_2}$ = ·024,993, $\bar{\eta}^2_{VA.I_2}$ = ·013,544 ± ·005,234.

The results here are distinctly puzzling, certainly the monocular and possibly the binocular table give a significant correlation ratio. On the other hand the correlation coefficients are not significant, and this points to a roughly symmetrical regression curve. Turning to the array-means we see that several have values significantly different from the general population means. Thus a maximum visual acuity is reached about $I_2 = 71{\cdot}95$, while there are significant minima at 67·95 and 75·95. That is to say, a maximum visual acuity appears to be reached extremely close to the mean or modal value of this cephalic index. It looks as if the head ratio H/L was more important ocularly than B/L. Diagram 153 shows the nature of the association (η' = ·1611

for monocular, and ·1254 for binocular vision); it is not very intense but may be a clue to something more important*.

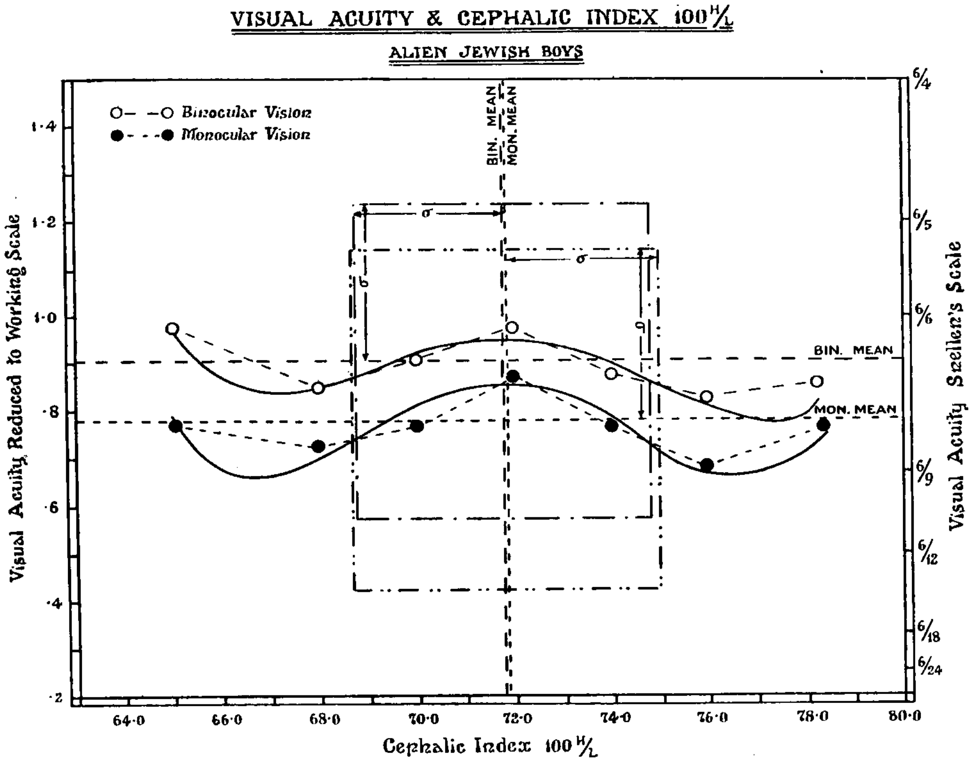

Diagram 153.

We have graduated the regression curves with quartics.

The third cephalic index, $I_3 = 100\ H/B$, now remains to be considered.

(v *a* and *b*) *Visual Acuity and Cephalic Index,* $I_3 = 100\ H/B$. Our data for both monocular and binocular vision are given in Tables CCCLI and CCCLII below. The array-means are as follows:

Monocular Vision: Grade of Cephalic Index, 100 H/B	Monocular Vision: Mean Visual Acuity	Binocular Vision: Grade of Cephalic Index, 100 H/B	Binocular Vision: Mean Visual Acuity
79·55	·7420 ± ·0341	79·63	·9453 ± ·0508
81·95	·8185 ± ·0252	81·95	·9689 ± ·0360
83·95	·7901 ± ·0198	83·95	·8951 ± ·0269
85·95	·7918 ± ·0154	85·95	·9212 ± ·0208
87·95	·8275 ± ·0183	87·95	·9400 ± ·0249
89·95	·7720 ± ·0198	89·95	·8574 ± ·0281
91·95	·7066 ± ·0263	91·95	·8583 ± ·0375
95·89	·6910 ± ·0288	95·42	·8157 ± ·0405
General Population[1]:	·7807 ± ·0076	General Population[1]:	·9047 ± ·0105

[1] Standard Deviations: Monocular Vision ·3592, Binocular Vision ·3286.

There is very little of definite significance to be made out of this series of means; probably a

* We formed a table of Visual Acuity and Absolute Auricular Height (H), with a view to an age corrected partial correlation. But we found the correlation coefficient: $r = -\ {\cdot}0496 \pm {\cdot}0211$, a scarcely significant value, and of no prognostic use. It might easily arise from Auricular Height increasing and Visual Acuity slightly decreasing with age. The correlation ratio gave

$$\eta'^2_{VA.H} = {\cdot}035{,}027, \qquad \bar{\eta}^2_{VA.H} = {\cdot}018{,}775 \pm {\cdot}004{,}068,$$

suggesting a significant but small $\eta'_{VA.H}$. The graph, however, provided no indications of real value, and we have not thought it worth while to publish it or the corresponding table. Mean Auricular Height = 127·907 mm.; Standard Deviation = 5·8353 mm.

very high ratio of auricular height to breadth does mark a somewhat reduced visual acuity. For the Product Moment Correlation we have:

$$r = -\cdot 0641 \pm \cdot 0211 \text{ for monocular,} \qquad r = -\cdot 0948 \pm \cdot 0317 \text{ for binocular vision,}$$

both denoting small but significant associations marking a fall in visual acuity with increase of the index.

On the other hand for the correlation ratio we have:

$$\eta'^2_{VA.I_3} = \cdot 012{,}789, \qquad \bar{\eta}^2_{VA.I_3} = \cdot 006{,}917 \pm \cdot 002{,}480 \text{ for monocular vision,}$$

$$\eta'^2_{VA.I_3} = \cdot 015{,}692, \qquad \bar{\eta}^2_{VA.I_3} = \cdot 015{,}730 \pm \cdot 005{,}621 \text{ for binocular vision,}$$

the first of which is, perhaps, and the second is not significant. They give $\eta'_{VA.I_3} = \cdot 1131$ and $\cdot 1253$ respectively, showing that what association there is is nearly linear. Diagram 154 shows the regressions.

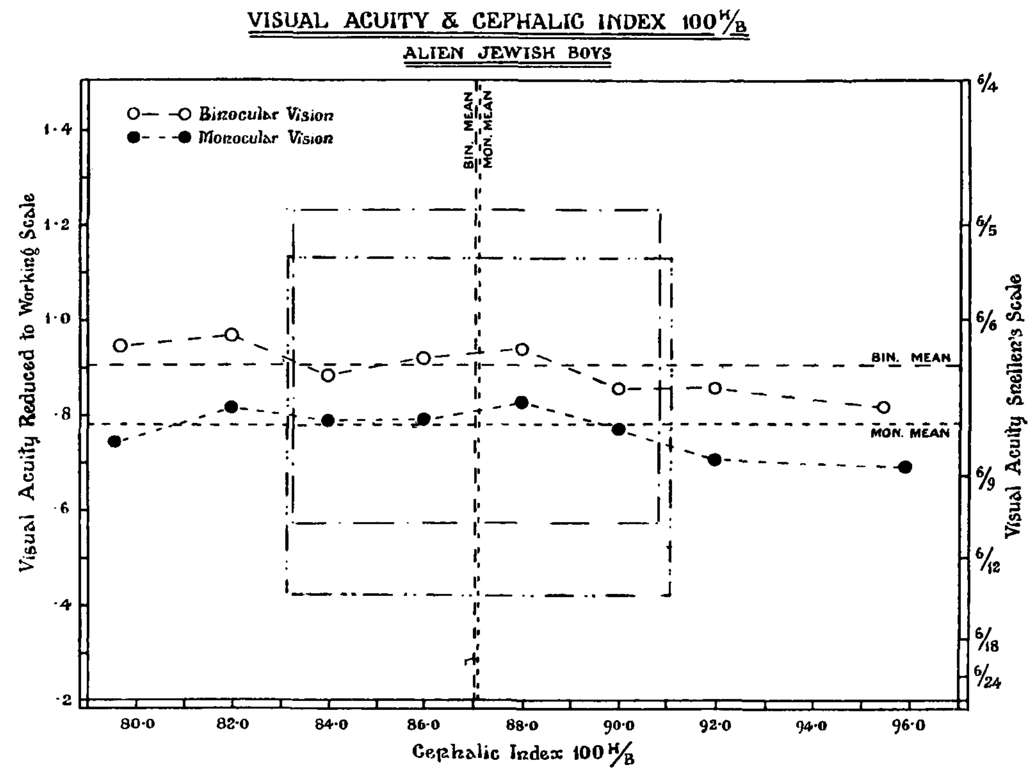

Diagram 154.

Tables CCCLI and CCCLII. *Visual Acuity (Monocular and Binocular) with* $I_3 = 100\ H/B$.

Index I_3: Central Values	Monocular Vision 1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals	Binocular Vision 1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
75·95	—	—	—	—	2	—	—	—	—	—	—	—	2	—	—	—	1	—	—	—	—	—	—	—	—	1
77·95	—	—	—	—	1	1	1	1	2	—	—	—	6	—	—	—	—	1	—	—	—	—	—	—	—	1
79·95	—	—	4	12	8	2	2	8	1	3	1	1	42	—	—	3	7	2	—	3	2	—	—	—	—	17
81·95	—	1	15	16	26	4	8	10	3	6	2	1	92	—	—	10	13	6	1	4	2	—	1	1	—	38
83·95	—	3	15	31	30	14	22	14	9	5	2	3	148	—	1	12	16	16	7	6	6	2	1	1	—	68
85·95	2	3	25	52	44	32	33	29	6	12	5	3	246	1	2	20	34	20	12	9	11	1	2	2	—	114
87·95	—	2	9	50	45	24	14	14	1	9	2	4	174	—	1	8	34	17	7	5	2	—	2	1	2	79
89·95	1	6	11	20	41	18	18	8	9	7	4	5	148	1	1	6	13	20	7	5	2	2	3	—	2	62
91·95	—	2	2	13	20	14	7	7	15	2	2	—	84	1	1	3	7	11	4	2	—	5	—	1	—	35
93·95	—	—	2	1	14	4	7	6	2	4	—	—	40	—	1	1	—	8	2	4	1	1	1	—	—	19
95·95	—	—	—	1	3	1	1	—	—	—	—	—	6	—	—	—	1	2	—	—	—	—	—	—	—	3
97·95	—	—	2	1	2	2	—	2	—	1	—	—	10	—	—	1	1	2	—	—	1	—	—	—	—	5
99·95	—	—	—	—	7	1	—	2	2	1	—	1	14	—	—	—	—	2	—	1	—	—	—	—	—	3
Totals	3	17	85	197	243	117	113	101	50	50	18	18	1012	3	7	64	127	107	40	39	27	11	10	6	4	445

The remaining constants are:

Mean Index, 100 H/B: Monocular 87·0923, Binocular 87·0556.

Standard Deviation of Index: „ 3·9680, „ 3·7792.

(vi a and b) *Visual Acuity and Interpupillary Index.* The interpupillary index is 100 × by the ratio of the distance between the pupils to the parietal breadth of the head. It is thus a relative measure of the distance of the eyes apart. Our data are contained in Tables CCCLIII and CCCLIV.

Tables CCCLIII and CCCLIV. *Visual Acuity and Interpupillary Index.*

Index Central Values	Monocular Vision												Totals	Binocular Vision												Totals
	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04		1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	
34·45	—	1	—	2	1	—	—	2	—	—	—	—	6	—	—	—	1	—	—	1	—	—	—	—	—	2
35·45	—	2	2	3	8	1	—	2	—	—	2	—	20	—	—	1	3	1	1	—	1	—	—	1	—	8
36·45	—	—	2	8	21	7	3	8	3	5	—	1	58	—	—	1	7	7	3	1	—	1	1	—	1	22
37·45	3	3	7	12	27	10	12	10	9	7	4	—	104	2	1	8	5	11	2	2	2	2	—	2	—	37
38·45	—	4	17	24	61	15	20	14	10	4	1	4	174	—	3	9	20	27	7	8	3	—	2	—	1	80
39·45	—	4	12	35	51	19	21	10	7	10	—	3	172	1	1	11	21	18	10	4	3	3	2	—	1	75
40·45	—	3	24	39	25	26	25	19	4	5	4	6	180	—	1	17	24	14	2	12	4	1	2	1	—	78
41·45	—	—	11	29	25	16	10	12	7	8	1	3	122	—	—	9	20	12	4	4	3	3	2	—	1	58
42·45	—	—	3	28	8	10	9	7	4	1	3	1	74	—	—	4	15	3	6	3	3	—	—	2	—	36
43·45	—	—	5	9	8	8	9	6	2	5	—	—	52	—	1	3	4	8	3	2	3	—	1	—	—	25
44·45	—	—	2	2	2	2	—	—	2	—	—	—	10	—	—	1	2	—	1	—	—	1	—	—	—	5
45·45	—	—	—	1	4	—	2	2	—	1	—	—	10	—	—	—	1	3	—	—	1	—	—	—	—	5
46·45	—	—	—	4	1	—	—	1	—	—	—	—	6	—	—	—	3	—	—	—	—	—	—	—	—	3
47·45	—	—	—	—	—	—	—	2	1	1	—	—	4	—	—	—	—	—	—	1	1	—	—	—	—	2
48·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49·45	—	—	—	—	—	1	1	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—	1
Totals	3	17	85	196	242	115	112	95	49	47	15	18	994	3	7	64	126	105	39	38	24	11	10	6	4	437

The constants of these tables are as follows:

Interpupillary Index, Mean: Monocular 39·8444, Binocular 40·0038.

„ „ Standard Deviation: „ 2·2136, „ 2·2168.

Visual Acuity, Mean: Monocular ·7876, Binocular ·9090.

„ „ Standard Deviation: „ ·3565, „ ·3280.

Product Moment Coefficient r:

Monocular $-$ ·0222 $\pm$ ·0213,

Binocular $-$ ·0180 $\pm$ ·0320.

Correlation Ratio:

Monocular $\eta'^2_{VA.IpI}$ = ·009,008, $\bar{\eta}^2_{VA.IpI}$ = ·009,054 $\pm$ ·002,865,

Binocular $\eta'^2_{VA.IpI}$ = ·006,760, $\bar{\eta}^2_{VA.IpI}$ = ·020,594 $\pm$ ·006,472.

Neither the correlation coefficients nor the correlation ratios can be considered as significant. The graphs seem to indicate a slightly parabolic form of the regression curves with a maximum near the modal value, 40, of the index, but the association is so slender, that we have not engraved them, nor published the array-means. We conclude that the relative distance apart of the pupils does not influence significantly even binocular vision.

(vii *a* and *b*) *Visual Acuity* (*Monocular and Binocular*) *and the Index of the Sunken Eye.* Our data are given in the tables below:

Tables CCCLV and CCCLVI. *Visual Acuity and the Index of Sunken Eye.*

Index Central Values	Monocular Vision												Totals	Binocular Vision												Totals
	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04		1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	
76·45	—	—	1	—	—	—	1	—	—	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	1
77·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
78·45	—	—	—	—	—	—	—	2	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
79·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
80·45	—	—	1	1	2	—	—	—	—	—	—	—	4	—	—	1	—	—	—	—	—	—	—	—	—	1
81·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
82·45	—	—	—	—	1	—	—	—	—	1	—	2	4	—	—	—	—	—	—	—	—	—	—	—	1	1
83·45	—	4	3	2	—	—	2	4	—	1	—	2	18	1	—	2	1	—	—	—	1	—	—	—	1	6
84·45	—	—	1	2	10	5	1	2	3	—	—	—	24	—	—	—	5	4	1	—	—	—	—	—	—	10
85·45	—	—	—	7	16	—	4	4	2	5	—	—	38	—	—	—	6	5	1	1	1	—	1	—	—	15
86·45	1	2	4	12	22	8	7	9	2	2	—	1	70	1	—	5	6	12	2	1	2	—	—	—	—	29
87·45	—	2	11	13	18	9	13	5	6	4	—	1	82	—	1	6	8	6	4	4	—	1	1	—	—	31
88·45	—	—	11	34	50	24	8	10	6	6	3	4	156	—	1	9	21	24	7	3	3	—	1	1	—	70
89·45	—	2	19	31	35	13	8	15	6	9	1	1	140	—	1	14	20	14	3	4	4	—	2	—	1	63
90·45	—	—	10	32	27	17	13	6	4	7	4	—	120	—	2	10	17	10	6	6	5	3	2	—	—	61
91·45	—	2	9	30	24	20	22	17	9	4	4	3	144	—	—	7	17	13	10	5	4	3	—	2	1	62
92·45	—	2	6	12	20	10	13	6	3	4	—	—	76	—	1	4	11	9	3	7	1	1	—	—	—	37
93·45	—	1	9	7	10	5	11	9	4	4	3	1	64	—	—	5	6	7	1	2	3	1	1	2	—	28
94·45	—	2	—	8	7	—	10	6	5	3	2	1	44	—	1	—	6	2	1	4	3	2	1	—	—	20
95·45	—	—	—	4	—	3	1	—	—	—	1	1	10	—	—	—	2	—	2	—	—	—	1	1	—	6
96·45	—	—	—	2	2	—	—	4	—	—	—	—	8	—	—	—	1	1	—	2	—	—	—	—	—	4
97·45	2	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	1
98·45	—	—	—	—	—	—	—	2	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
99·45	—	—	—	—	—	2	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	3	17	85	197	244	116	114	101	50	50	18	17	1012	3	7	64	127	107	41	39	27	11	10	6	4	446

The constants of these tables are as follows:

Index of Sunken Eye, Mean: Monocular 89·7069, Binocular 89·8670.

„ Standard Deviation: „ 2·9261, „ 2·7656.

Acuity of Vision, Mean: Monocular ·7814, Binocular ·9044.

„ „ Standard Deviation: „ ·3585, „ ·3284.

Product Moment Correlation r:

Monocular $- \cdot 0541 \pm \cdot 0211$,

Binocular $- \cdot 1416 \pm \cdot 0310$.

Correlation Ratio:

Monocular $\eta'^2_{VA.SEI} = \cdot 017{,}132$, $\bar{\eta}^2_{VA.SEI} = \cdot 009{,}881 \pm \cdot 002{,}966$,

Binocular $\eta'^2_{VA.SEI} = \cdot 029{,}618$, $\bar{\eta}^2_{VA.SEI} = \cdot 022{,}442 \pm \cdot 006{,}690$.

It will be seen that the correlation coefficients indicate some significance although their intensity is small. This is not conclusively confirmed by the correlation ratios. If we treat them as significant we have $\eta'_{VA.SEI} = \cdot 1309$ and $\cdot 1721$ respectively, which indicate that the association if real can hardly be considered linear. Since the correlation coefficients are negative, i.e. the more protuberant the eye, the less the visual acuity, the small correlations cannot be a secondary effect of age, for Visual Acuity (Vol. II, p. 123) and the Index of the Sunken Eye (Vol. II, p. 137) both *decrease* with age, so that the secondary effect would be marked by a *positive* correlation.

The array-means are given below and Diagram 155 contains a graph of the regression curves graduated by unweighted cubics.

Array-Means

Monocular: Grade of Index of Sunken Eye	Monocular: Mean Visual Acuity	Binocular: Grade of Index of Sunken Eye	Binocular: Mean Visual Acuity
82·027	·7503 ± ·0441	82·228	·9133 ± ·0738
85·063	·7381 ± ·0307	85·05	·9196 ± ·0443
86·45	·8144 ± ·0289	86·45	·9776 ± ·0411
87·45	·8054 ± ·0267	87·45	·9416 ± ·0398
88·45	·8110 ± ·0194	88·45	·9497 ± ·0265
89·45	·8314 ± ·0204	89·45	·9646 ± ·0279
90·45	·8150 ± ·0221	90·45	·8939 ± ·0284
91·45	·7420 ± ·0202	91·45	·8477 ± ·0281
92·45	·7978 ± ·0277	92·45	·9159 ± ·0364
93·45	·7059 ± ·0302	93·45	·8232 ± ·0419
95·185	·6778 ± ·0293	94·998	·7523 ± ·0398
General Population:	·7814 ± ·0076	General Population:	·9044 ± ·0105

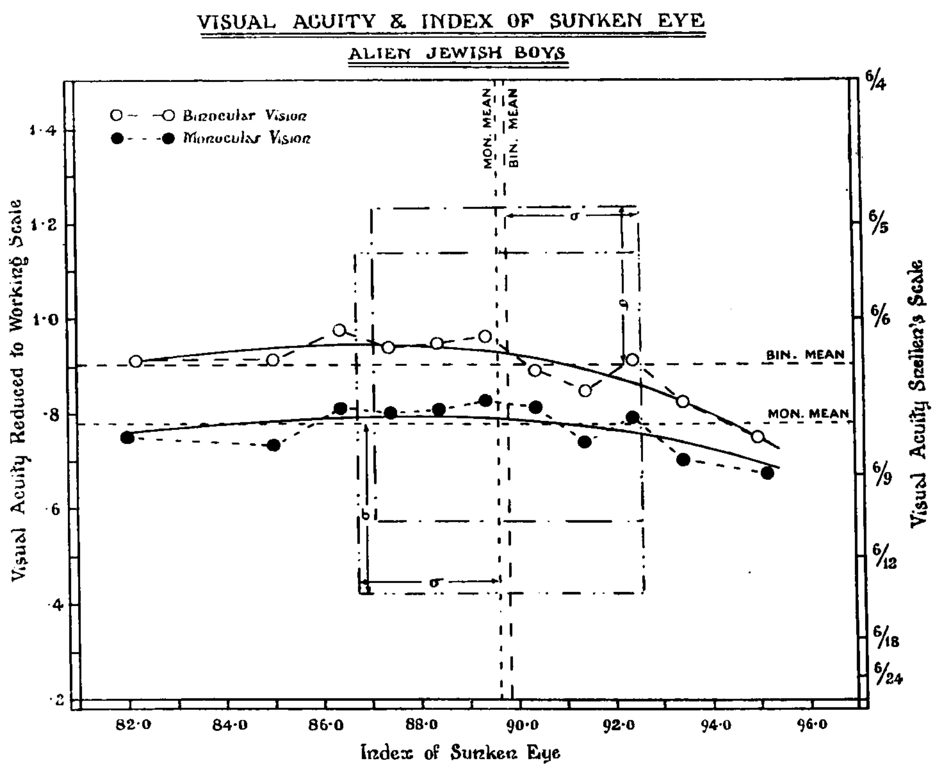

Diagram 155.

Both series suggest a more or less orderly sequence beneath the random variations, the visual acuity reaching a maximum with the modal value of the index and decreasing on either side of it. Such a state of affairs is what we should expect on any theory of selective evolution, the effectiveness of the eye modelling the skull, and not the skull limiting the efficiency of the eye.

The stress we lay is on the general orderliness of the series of array-means, which only in one or two individual cases border on significant differences. On the whole, believing that vision is largely a hereditary character, we have been disappointed in not finding higher correlations with the craniometric measurements. At the same time visual acuity is only, so to speak, a useful summary of the efficiency of the various factors which modify vision, and before asserting that

cranial characters do not influence vision, it will be of value to ascertain whether the individual factors of vision have equally small associations.

(*b*) *Refraction Class.* The pigmentation data are given in the accompanying contingency tables.

(i *a* and *b*) *Refraction Class and Pigmentation.*

Tables CCCLVII and CCCLVIII. *Refraction Class and Eye and Hair Colours.*

Eye Colour

Refraction Class	Dark Brown	Medium Brown	Light Brown	Hazel	Grey	Blue Grey	Pure Blue	Totals
Emmetropia	44 (+3·75)	159 (+·51)	95 (−4·37)	104 (+2·11)	89 (+5·98)	54 (−5·12)	16 (−2·87)	561[1]
Hypermetropia ...	10 (+5·12)	16 (−3·21)	7 (−5·04)	14 (+1·65)	6 (−4·06)	11 (+3·83)	4 (+1·71)	68
Hypermetropic Astigmatism	3 (−1·88)	14 (−5·21)	14 (+1·96)	13 (+·65)	6 (−4·06)	12 (+4·83)	6 (+3·71)	68
Mixed Astigmatism ...	0 (−·93)	4 (+·33)	2 (−·30)	3 (+·64)	1 (−·93)	3 (+1·63)	0 (−·44)	13
Myopic Astigmatism	0 (−2·87)	9 (−2·30)	7 (−·09)	7 (−·26)	12 (+6·08)	5 (+·79)	0 (−1·35)	40
Myopia	7 (−3·19)	50 (+9·88)	33 (+7·85)	21 (−4·79)	18 (−3·01)	9 (−5·96)	4 (−·78)	142[1]
Totals	64	252	158	162	132	94	30	892

Hair Colour

Refraction Class	Black	Very Dark Brown	Dark Brown	Medium Brown	Light Brown	Slatey	Red	Totals
Emmetropia	21 (−1·60)	115·5 (−1·90)	143·5 (−6·55)	175 (+11·77)	90 (+2·11)	11 (+·96)	4 (−4·79)	560[1]
Hypermetropia ...	9 (+6·26)	15 (+·74)	16 (−2·22)	13 (−6·82)	11 (+·33)	2 (+·78)	2 (+·93)	68
Hypermetropic Astigmatism	0 (−2·74)	15·5 (+1·24)	27·5 (+9·28)	13 (−6·82)	12 (+1·33)	0 (−1·22)	0 (−1·07)	68
Mixed Astigmatism ...	0 (−·53)	2 (−·73)	3 (−·48)	7 (+3·21)	1 (−1·04)	0 (−·23)	0 (−·20)	13
Myopic Astigmatism	3 (+1·39)	6 (−2·39)	12 (+1·28)	9 (−2·66)	7 (+·72)	2 (+1·28)	1 (+·37)	40
Myopia	3 (−2·77)	33 (+3·02)	37 (−1·32)	43 (+1·32)	19 (−3·44)	1 (−1·57)	7 (+4·76)	143[1]
Totals	36	187	239	260	140	16	14	892

[1] 894 cases were observed, but for one boy there was no eye colour, for another no hair colour recorded.

Working these tables as mean square contingency tables we have:

For Eye Colour and Refraction Class: $\phi'^2 = \cdot 059{,}779$, $\bar{\phi}^2 = \cdot 045{,}964 \pm \cdot 007{,}189$.

For Hair Colour and Refraction Class: $\phi'^2 = \cdot 065{,}733$, $\bar{\phi}^2 = \cdot 045{,}964 \pm \cdot 007{,}669$.

In neither case can we definitely assert that association probably exists. The mean square contingency coefficient would be ·2375 in the first and ·2483 in the second case. If we take dichotomies giving as nearly as possible equal eye and hair frequencies, and separate the normal refracting from the ametropic eyes, we have the following tetrachoric tables, which show at once that the correlations are negative, i.e. the less pigment, the more normal the eye is likely to be:

	Darker Eyes	Lighter Eyes	Totals	Darker Hair	Lighter Hair	Totals
Emmetropia	298	263	561	280	280	560
Ametropia	176	155	331	182	150	332
Totals	474	418	892	462	430	892

The tetrachoric correlation coefficients are:

For Eye Colour, $r_t = -\cdot 0008$; for Hair Colour, $r_t = -\cdot 0746$.

No stress can be laid on these values, other than as an indication that the association is very small, and that those boys with the darker pigmentation probably have the poorer eyes. In Tables CCCLVII and CCCLVIII we have placed in brackets under the cell frequencies the excess or defect from the independent frequencies. It will be seen at once that the grey and blue eyes have a deficiency of myopia and the blue an excess of hypermetropia, while the medium and light brown eyes have an excess of myopia and a deficiency of hypermetropia. The relationships are naturally less obvious in the hair colour table. The evidence of the eye colour table, if not very weighty, is in favour of the lighter eyes being a racial admixture and the myopia of the Jews being really a racial character. It is possible that in the extremely dark eyes at the other end of the scale we have also some evidence of a second racial admixture from a race with much better sight than the Jewish.

(ii) *Refraction Class and Cephalic Indices.*

(*a*) *Refraction Class and Cephalic Index,* $I_1 = 100\ B/L$. Our data are provided in Table CCCLIX.

Table CCCLIX. *Refraction Class and Cephalic Index,* $I_1 = 100\ B/L$.

Cephalic Index, 100 B/L (Central Values)

Refraction Class	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	Totals
Emmetropia ...	1	—	6	20	61	105	104	135	85	29	13	4	563
Hypermetropia ...	—	—	2	—	5	11	21	12	12	4	—	2	69
Hypermetropic Astigmatism ...	2	—	—	3	6	10	7	20	12	7	1	1	69
Mixed Astigmatism	—	—	—	—	2	1	—	4	4	—	1	1	13
Myopic Astigmatism	—	—	—	—	4	10	9	11	1	3	2	—	40
Myopia	3	2	—	11	14	23	33	28	18	5	3	—	140
Totals	6	2	8	34	92	160	174	210	132	48	20	8	894

The means of the arrays are as follows:

Refraction Class	Mean Cephalic Index, 100 B/L
Emmetropia	$82\cdot 4722 \pm \cdot 1005$
Hypermetropia	$82\cdot 7906 \pm \cdot 2870$
Hypermetropic Astigmatism	$82\cdot 8486 \pm \cdot 2870$
Mixed Astigmatism ...	$84\cdot 4115 \pm \cdot 6612$
Myopic Astigmatism ...	$82\cdot 5500 \pm \cdot 3770$
Myopia	$81\cdot 6500 \pm \cdot 2015$
General Population[1] ...	$82\cdot 4287 \pm \cdot 0797$

[1] Standard Deviation of Cephalic Index, 100 B/L, 3·5346.

It is clear that only two deviations from the General Population's Mean Index are significant, those for Mixed Astigmatism and for Myopia. The myopes are slightly more dolichocephalic, or better, rather less brachycephalic than the Jewish boys as a whole. The boys with Mixed Astigmatism are markedly more brachycephalic, but, notwithstanding the significance of their index divergence, the small numbers in this class render the result suspicious. Taking into account the absence of myopes among the light-eyed boys, it is somewhat surprising to find that the myopes are characterised by more dolichocephaly. The result is confirmed roughly by the method of percentages. Dividing the population at a cephalic index of 82·95 we find that the general population has 15·66 % of myopes; the moiety of the population on the dolichocephalic side of 82·95 has 18·07 % and the moiety on the brachycephalic side has 12·92 % of myopes. The conclusion

must be that the light-eyed race of which we suspect an admixture was more likely to have been Slavonic than Nordic.

The association of Refraction Class and Cephalic Index is of course slender. We have:

$$\eta'^2_{CI_1.RC} = \cdot 014{,}223, \qquad \bar{\eta}^2_{CI_1.RC} = \cdot 005{,}593 \pm \cdot 002{,}380,$$

which give rise to a probably significant uncorrected correlation ratio: $\eta'_{CI_1.RC} = \cdot 1193$.

(β) *Refraction Class and Cephalic Index*, $I_2 = 100\, H/L$. The data are given in Table CCCLX. The mean value of I_2 is 71·9187 and the standard deviation of this index is 3·1369. The array-means are provided below:

Table CCCLX. *Refraction Class and Cephalic Index*, $I_2 = 100\, H/L$.

Cephalic Index, 100 H/L (Central Values)

Refraction Class	59·95	61·95	63·95	65·95	67·95	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	Totals
Emmetropia	2	1	3	15	65	130	159	106	48	34	—	—	—	563
Hypermetropia	—	—	—	3	—	9	18	23	4	12	—	—	—	69
Hypermetropic Astigmatism	—	—	—	7	12	15	11	14	5	4	1	—	—	69
Mixed Astigmatism ...	—	—	—	—	2	1	2	4	1	2	1	—	—	13
Myopic Astigmatism ...	—	—	—	1	4	13	9	6	1	2	2	—	2	40
Myopia	—	1	5	4	17	36	33	19	21	4	—	—	—	140
Totals	2	2	8	30	100	204	232	172	80	58	4	—	2	894

Refraction Class	Mean Cephalic Index, 100 H/L
Emmetropia	71·8434 ±·1833
Hypermetropia	72·0920 ±·2547
Hypermetropic Astigmatism	71·3703 ±·2547
Mixed Astigmatism ...	73·6423 ±·5868
Myopic Astigmatism ...	72·4500 ±·3346
Myopia	72·4357 ±·1788
General Population ...	71·9187 ±·0708

Except in the case of Mixed Astigmatism and Myopia none of these values approaches significant differentiation. Considering the correlation ratio of Cephalic Index I_2 on Refraction Class we have:

$$\eta'^2_{CI_2.RC} = \cdot 028{,}208, \qquad \bar{\eta}^2_{CI_2.RC} = \cdot 005{,}593 \pm \cdot 002{,}380,$$

which give a significant correlation ratio of $\eta'_{CI_2.RC} = \cdot 1680$. But it is difficult to discover any real relation except in the very small class of Mixed Astigmatism. As this class is not differentiated in the case of the third cephalic index, 100 H/B, we are led to the suggestion—it cannot be called anything like a proof—that mixed astigmatism may be associated with heads disproportionately short as compared with their breadth or with their auricular height. The correlations of the orbital index of the skull with cephalic indices of the skull are small (under ·10), but some index based on the *depth* of the orbit might give more significant results.

(γ) *Refraction Class and Cephalic Index*, $I_3 = 100\, H/B$. Table CCCLXI contains our data.

Table CCCLXI. *Refraction Class and Cephalic Index*, $I_3 = 100\, H/B$.

Cephalic Index, 100 H/B (Central Values)

Refraction Class	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	93·95	95·95	97·95	99·95	Totals
Emmetropia	2	—	18	45	74	153	119	83	39	16	5	6	5	565
Hypermetropia	—	1	2	3	9	12	10	12	9	6	1	2	2	69
Hypermetropic Astigmatism	—	3	2	7	14	21	3	12	5	2	—	—	—	69
Mixed Astigmatism ...	—	—	1	2	1	3	2	1	1	1	—	—	1	13
Myopic Astigmatism ...	—	—	1	5	3	9	6	9	2	2	—	—	3	40
Myopia	—	—	6	12	19	24	24	27	16	9	—	2	3	142
Totals	2	4	30	74	120	222	164	144	72	36	6	10	14	898

Mean Cephalic Index, 100 H/B = 87·3219, with Standard Deviation 3·9273.

The array-means are as follows:

Refraction Class	Mean Cephalic Index, 100 H/B
Emmetropia	$87{\cdot}1323 \pm {\cdot}1122$
Hypermetropia	$88{\cdot}5877 \pm {\cdot}3189$
Hypermetropic Astigmatism	$86{\cdot}0659 \pm {\cdot}3189$
Mixed Astigmatism ...	$87{\cdot}4885 \pm {\cdot}7347$
Myopic Astigmatism ...	$88{\cdot}1000 \pm {\cdot}4188$
Myopia	$87{\cdot}8357 \pm {\cdot}2223$
General Population ...	$87{\cdot}3219 \pm {\cdot}0884$

The only arrays with probably some significant differentiation are those for Hypermetropia and for Hypermetropic Astigmatism, which, however, vary in opposite senses. We have:

$$\eta'^2_{CI_3.RC} = {\cdot}021{,}807, \qquad \bar{\eta}^2_{CI_3.RC} = {\cdot}005{,}567 \pm {\cdot}002{,}368,$$

showing that the correlation ratio ($\eta'_{CI_3.RC} = {\cdot}1477$) is significant.

It must be remarked that our treatment of the three cephalic indices is not wholly satisfactory, because we have been considering whether any refraction class is accompanied by a special shape of head, whereas the more reasonable inquiry is the reverse of this, namely to ascertain whether heads of special shape are endowed with differentiated sight. As the statistician well knows the two problems are not quite the same. Unfortunately we cannot place these refraction classes in any graduated order, and the only mode of approaching the problem seems to be the unsatisfactory method of percentages.

Table CCCLXII. *Percentages of each Refraction Class of the several Head Shapes.*

Cephalic Index Values

	$I_1 = 100\,B/L$			$I_2 = 100\,H/L$			$I_3 = 100\,H/B$			General Population
	<80·95	80·95–84·95	>84·95	<70·95	70·95–72·95	>72·95	<84·95	84·95–88·95	> 88·95	
No. in Group ...	302	384	208	346	232	316	230	386	282	894–898
Emmetropia	$63{\cdot}9 \pm 1{\cdot}9$	$62{\cdot}2 \pm 1{\cdot}7$	$63{\cdot}0 \pm 2{\cdot}3$	$62{\cdot}4 \pm 1{\cdot}8$	$68{\cdot}5 \pm 2{\cdot}1$	$59{\cdot}5 \pm 1{\cdot}8$	$60{\cdot}4 \pm 2{\cdot}1$	$70{\cdot}5 \pm 1{\cdot}7$	$54{\cdot}6 \pm 1{\cdot}9$	$62{\cdot}9 \pm 1{\cdot}1$
Hypermetropia	$6{\cdot}0 \pm 1{\cdot}0$	$8{\cdot}6 \pm 0{\cdot}9$	$8{\cdot}7 \pm 1{\cdot}2$	$3{\cdot}5 \pm 1{\cdot}0$	$7{\cdot}8 \pm 1{\cdot}2$	$12{\cdot}3 \pm 1{\cdot}0$	$6{\cdot}5 \pm 1{\cdot}2$	$5{\cdot}7 \pm 0{\cdot}9$	$11{\cdot}3 \pm 1{\cdot}1$	$7{\cdot}7 \pm 0{\cdot}6$
Hypermetropic Astigmatism[1]	$7{\cdot}5 \pm 1{\cdot}1$	$7{\cdot}6 \pm 1{\cdot}0$	$11{\cdot}5 \pm 1{\cdot}3$	$10{\cdot}3 \pm 1{\cdot}0$	$5{\cdot}2 \pm 1{\cdot}2$	$8{\cdot}9 \pm 1{\cdot}1$	$12{\cdot}2 \pm 1{\cdot}2$	$6{\cdot}9 \pm 1{\cdot}0$	$7{\cdot}4 \pm 1{\cdot}1$	$8{\cdot}4 \pm 0{\cdot}6$
Myopic Astigmatism[1]	$5{\cdot}1 \pm 0{\cdot}9$	$5{\cdot}7 \pm 0{\cdot}8$	$4{\cdot}3 \pm 1{\cdot}0$	$5{\cdot}6 \pm 0{\cdot}8$	$4{\cdot}3 \pm 1{\cdot}0$	$5{\cdot}4 \pm 0{\cdot}8$	$4{\cdot}8 \pm 1{\cdot}0$	$4{\cdot}5 \pm 0{\cdot}8$	$6{\cdot}4 \pm 0{\cdot}9$	$5{\cdot}2 \pm 0{\cdot}5$
Myopia	$17{\cdot}5 \pm 1{\cdot}4$	$15{\cdot}9 \pm 1{\cdot}3$	$12{\cdot}5 \pm 1{\cdot}7$	$18{\cdot}2 \pm 1{\cdot}3$	$14{\cdot}2 \pm 1{\cdot}6$	$13{\cdot}9 \pm 1{\cdot}4$	$16{\cdot}1 \pm 1{\cdot}6$	$12{\cdot}4 \pm 1{\cdot}3$	$20{\cdot}3 \pm 1{\cdot}5$	$15{\cdot}8 \pm 0{\cdot}8$

[1] The few cases (13) of Mixed Astigmatism were divided between the Hypermetropic and Myopic Astigmatisms.

Taking the indices in turn we note:

(α) Index $I_1 = 100\,B/L$: the only possibly significant changes are (a_1) an increased Hypermetropic Astigmatism with increased brachycephaly, (a_2) a decreased Myopia prevalence with increased brachycephaly. The latter result is in agreement with the result obtained on p. 213, that the myopes were more dolichocephalic.

(β) Index $I_2 = 100\,H/L$: (b_1) possibly but not definitely the heads nearer the mode have a greater percentage of Emmetropia, (b_2) there is a significant rise in the Hypermetropia as the heads become more hypsicephalic, i.e. relatively higher-headed, (b_3) there is possibly, but less certainly, a reduction of Myopia with hypsicephaly.

(γ) Index $I_3 = 100\,H/B$: (c_1) almost certainly the modal heads for this index have more normal eyes than those with values lying in the outside ranges, (c_2) there is possibly a significant increase

in Hypermetropia (with a decrease in Hypermetropic Astigmatism) as we pass from tapeinocephalic to acrocephalic heads, (c_3) the modal head for I_3 appears to have less frequency of Myopia than those either at the tapeinocephalic or acrocephalic ends of the scale. The evolutionary value of better vision associated with the modal head shape need scarcely be again emphasised. The means of the cephalic indices for the several Refraction Classes are given in the radiogram, Diagram 156, and in Diagram 157 we have given the percentages of each Refraction Class for the several head shapes.

REFRACTION CLASS & CEPHALIC INDICES
ALIEN JEWISH BOYS

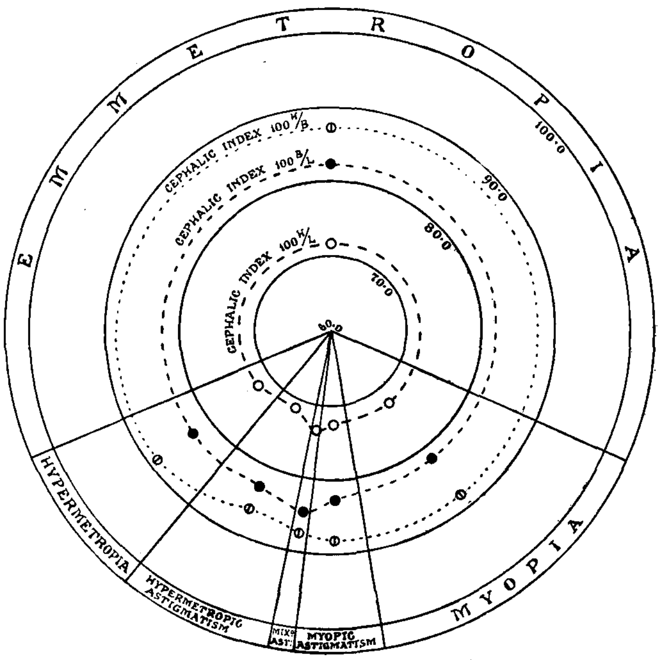

Diagram 156.

PERCENTAGES OF EACH REFRACTION CLASS
FOR THE SEVERAL HEAD SHAPES
ALIEN JEWISH BOYS

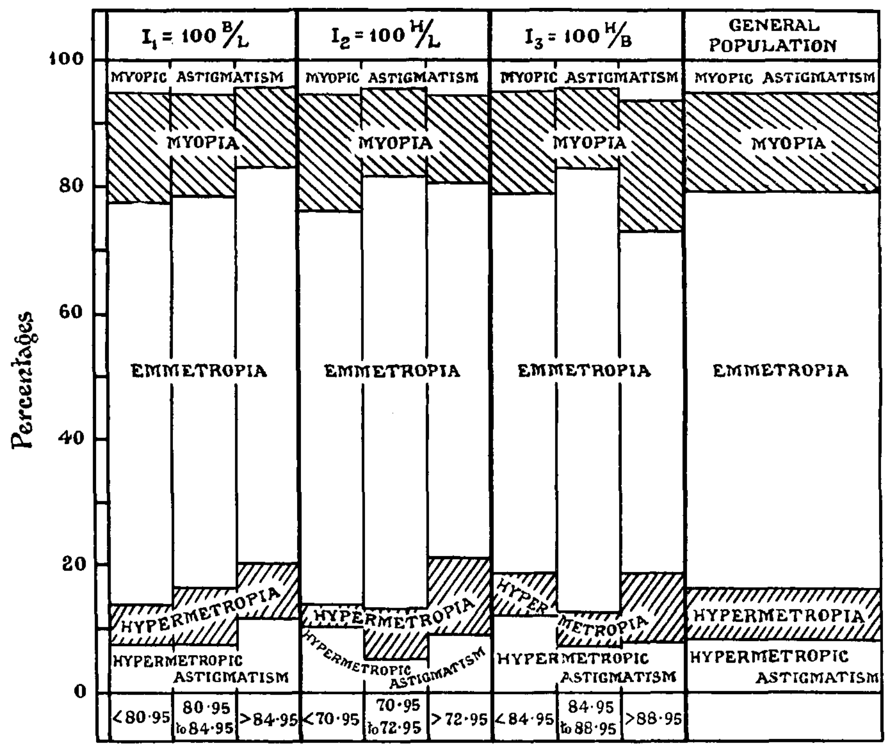

Diagram 157.

The results reached cannot, having regard to the size of the probable errors, be taken as more than suggestions. But they do demand a larger inquiry in which a far more elaborate system of head measurements should be taken. All we can venture to say at present is that there appears to be some, if by no means an intense association between Refraction Class and shape of the head.

(iii) *Refraction Class and Interpupillary Index.* We remind the reader that this index is a measure of the relative distance of the eyes apart, i.e. it equals 100 × Interpupillary Distance ÷ maximum parietal Breadth. The data are provided in Table CCCLXIII, and the correlation ratio of Index on Refraction Class is determined by

$$\eta'^2_{IpI.RC} = \cdot 019{,}746, \qquad \bar{\eta}^2_{IpI.RC} = \cdot 005{,}669 \pm \cdot 002{,}411.$$

This indicates a significant, if not very intense, correlation ratio $\eta'_{IpI.RC} = \cdot 1405$.

The array-means are as follows:

Refraction Class	Mean Interpupillary Index
Emmetropia	39·8763 ± ·0631
Hypermetropia	38·7187 ± ·1829
Hypermetropic Astigmatism	39·9254 ± ·1917
Mixed Astigmatism ...	39·7577 ± ·4153
Myopic Astigmatism ...	39·9750 ± ·2368
Myopia	39·9210 ± ·1275
General Population[1] ...	39·8015 ± ·0504

[1] Standard Deviation 2·2202.

The sole array which shows differentiation is that for the Hypermetropes, or we conclude that there is a tendency for Hypermetropes to have their eyes relatively close together. It is idle to publish a graph showing only a single significant deviation from the line of the population mean.

Table CCCLXIII. *Refraction Class and Interpupillary Index.*

Interpupillary Index (Central Values)

Refraction Class	34·45	35·45	36·45	37·45	38·45	39·45	40·45	41·45	42·45	43·45	44·45	45·45	46·45	47·45	48·45	49·45	Totals
Emmetropia	2	15	27	55	103	96	107	65	48	28	5	4	6	—	—	2	563
Hypermetropia ...	2	1	9	8	19	16	4	4	3	—	—	1	—	—	—	—	67
Hypermetropic Astigmatism	—	—	2	5	14	13	10	8	5	2	2	—	—	—	—	—	61
Mixed Astigmatism ...	—	—	—	—	4	4	2	3	—	—	—	—	—	—	—	—	13
Myopic Astigmatism	—	—	4	4	6	5	8	5	4	3	1	—	—	—	—	—	40
Myopia	2	2	6	22	24	22	19	13	10	11	—	3	—	4	—	—	138
Totals	6	18	48	94	170	156	150	98	70	44	8	8	6	4	—	2	882

Looked at the reverse way from the standpoint of percentages we find:

Interpupillary Index Percentages

Refraction Class	Small <38·95	Medium 38·95–40·95	Large >40·95	General Population
Emmetropia	60·1 ± 1·8	66·3 ± 1·9	65·8 ± 2·1	63·8 ± 1·1
Hypermetropia	11·6 ± 1·0	6·6 ± 1·0	3·3 ± 1·2	7·6 ± 0·6
Hypermetropic Astigmatism[1]	6·8 ± 1·0	8·5 ± 1·0	7·7 ± 1·2	7·6 ± 0·6
Myopic Astigmatism[1] ...	4·8 ± 0·8	5·2 ± 0·9	6·1 ± 1·0	5·3 ± 0·5
Myopia	16·7 ± 1·3	13·4 ± 1·4	17·1 ± 1·6	15·7 ± 0·8
No. in Population	336	306	240	882

[1] Mixed Astigmatics, very few in number, were divided as before.

There is very little of real significance in these percentage differences, beyond the reduction in Hypermetropia as the pupils get relatively farther apart. It is possible, but certainly not proven from this material, that the modal value of the interpupillary index corresponds to a maximum of emmetropic and a minimum of myopic eyes.

(iv) *Refraction Class and Index of Sunken Eye.* The reader may be reminded that the larger the index the less sunk is the eye, i.e. a large index denotes protuberance of the eyeball. The data are given in Table CCCLXIV. We have:

Mean Index: 89·6816, Standard Deviation of Index: 2·8192.

$$\eta'^2_{SEI.RC} = \cdot 004{,}272, \qquad \bar{\eta}^2_{SEI.RC} = \cdot 005{,}568 \pm \cdot 002{,}368.$$

Thus we cannot affirm any significant association.

Table CCCLXIV. *Refraction Class and Index of Sunken Eye.*

Index of Sunken Eye (Central Values)

Refraction Class	78·45	79·45	80·45	81·45	82·45	83·45	84·45	85·45	86·45	87·45	88·45	89·45	90·45	91·45	92·45	93·45	94·45	95·45	96·45	97·45	98·45	99·45	Totals
Emmetropia ...	—	—	2	—	—	6	13	20	43	49	99	71	76	77	46	33	18	6	4	1	—	1	565
Hypermetropia	—	—	2	—	—	2	1	2	3	6	12	15	4	11	5	2	2	—	—	1	—	1	69
Hypermetropic Astigmatism	2	—	—	—	—	4	1	3	4	8	10	7	6	13	3	1	7	—	—	—	—	—	69
Mixed Astigmatism ...	—	—	—	—	—	—	—	—	3	—	2	2	1	2	1	—	2	—	—	—	—	—	13
Myopic Astigmatism ...	—	—	—	—	2	—	—	2	3	3	5	5	6	3	5	3	1	2	—	—	—	—	40
Myopia ...	—	—	—	—	—	4	9	7	4	8	16	16	19	24	14	15	4	2	—	—	—	—	142
Totals ...	2	—	4	—	2	16	24	34	60	74	144	116	112	130	74	54	34	10	4	2	—	2	898

The means of the arrays are as follows:

Refraction Class	Mean Index of Sunken Eye
Emmetropia	89·7102 ±·0800
Hypermetropia	89·4645 ±·2289
Hypermetropic Astigmatism	89·1457 ±·2289
Mixed Astigmatism ...	89·9885 ±·5274
Myopic Astigmatism ...	89·8000 ±·3007
Myopia	89·8725 ±·1596
General Population ...	89·6816 ±·0635

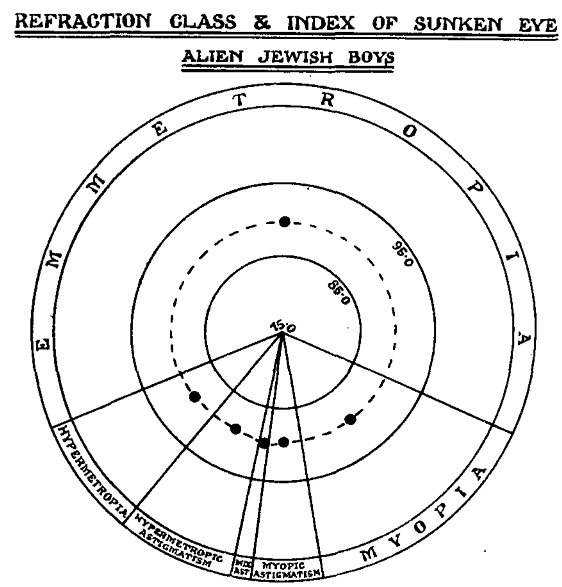

Diagram 158.

Of these array-means the Hypermetropic Astigmatic is possibly, but not definitely, significant. We should conclude from this result that the Hypermetropes have a more sunken eye than the Emmetropes.

Lastly we may turn the inquiry round and use percentages on three grades of ocular protuberance.

Index of Sunken Eye Percentages

Ranges	Recedent[1] <88·95	Equipoised 88·95–90·95	Protuberant >90·95	General Population 77·95–99·95
Emmetropia	64·4 ±1·7	64·5 ±2·2	60·0 ±1·9	62·9 ±1·1
Hypermetropia	7·8 ±0·9	8·3 ±1·2	7·1 ±1·0	7·7 ±0·6
Hypermetropic Astigmatism[2]	9·6 ±1·0	6·4 ±1·2	8·5 ±1·1	8·4 ±0·6
Myopic Astigmatism[2] ...	4·9 ±0·8	5·5 ±1·0	5·3 ±0·9	5·2 ±0·5
Myopia	13·3 ±1·3	15·3 ±1·6	19·0 ±1·4	15·8 ±0·8
No. in Population	360	228	310	898

[1] The three classes might possibly be called "catorthopic," "orthopic" and "proorthopic," and the index the "orthopic index."

[2] The few Mixed Astigmatics (13 in all) are divided between the Hypermetropic and Myopic Astigmatisms.

Here the only horizontal series which approaches significance is that for Myopia, the percentages of which increase as the eye becomes more protuberant. We consider that protuberance of the eye is probably associated with short sight*. Diagram 158 marks the smallness of the Association.

* Our observation seems to show that the Pekinese dogs with their protuberant eyes do not like fox-terriers see their masters at a distance, they trust to scent and sound.

On the whole we anticipated rather more relationship would have been discoverable between the shape of the head and Refraction Class. We have, however, to remember that the latter ocular character is really due to a complicated system of factors, and if any one of these were closely related to the shape of the head, its influence might be obscured by the others.

(*c*) *General Refraction.*

(i *a* and *b*) *General Refraction and Eye and Hair Colours.* Tables CCCLXV and CCCLXVI provide our data, the scales being as noted in earlier sections.

Tables CCCLXV and CCCLXVI. *General Refraction and Eye and Hair Colours.*

General Refraction in Dioptres (Central Values)

(*a*) Eye Classes	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	..	−12·75	..	−15·75	Totals
Dark Brown	—	—	2	—	—	1	6	1	10	37	5	2	—	—	—	—	—	—	—	..	—	..	—	64
Medium Brown	—	—	—	—	1	1	8	12	49	128	21	13	5	2	5	—	6	—	1	..	—	..	—	252
Light Brown	—	3	—	—	2	4	5	—	35	69	20	10	7	2	1	—	—	—	—	..	—	..	—	158
Hazel	—	1	—	4	3	—	6	3	37	80	18	4	2	—	—	—	—	1	1	..	1	..	1	162
Grey	—	—	—	—	6	2	1	1	22	73	8	4	9	1	2	—	1	—	2	..	—	..	—	132
Blue Grey	—	—	1	—	4	3	4	4	25	43	6	2	2	—	—	—	—	—	—	..	—	..	—	94
Pure Blue	1	—	1	—	1	—	1	4	8	9	5	—	—	—	—	—	—	—	—	..	—	..	—	30
Totals	1	4	4	4	17	11	31	25	186	439	83	35	25	5	8	—	7	1	4	..	1	..	1	892
(*b*) Hair Classes																								
Black	—	—	—	—	2	3	2	2	6	15	1	2	1	—	—	—	—	—	—	..	1	..	1	36
V. Dark Brown	—	—	2	—	1	—	8	9	46	84	20	6	4	1	3	—	3	—	—	..	—	..	—	187
Dark Brown	—	1	—	3	6	6	9	3	55	112	21	10	8	1	1	—	3	—	—	..	—	..	—	239
Medium Brown	—	—	—	1	3	2	8	5	45	146	18	13	7	3	3	—	1	1	4	..	—	..	—	260
Light Brown[1]	1	3	2	—	3	—	3	4	25	59	19	4	3	—	—	—	—	—	—	..	—	..	—	126
Lightest Brown[2]	—	—	—	—	2	—	1	1	2	8	—	—	—	—	—	—	—	—	—	..	—	..	—	14
Slatey	—	—	—	—	—	—	—	—	4	10	—	—	1	—	1	—	—	—	—	..	—	..	—	16
Red	—	—	—	—	—	—	—	1	3	4	4	—	—	2	—	—	—	—	—	..	—	..	—	14
Totals	1	4	4	4	17	11	31	25	186	438	83	35	24	7	8	—	7	1	4	..	1	..	1	892

[1] Nos. 8, 9, 10 of Fischer's Scale. [2] Nos. 11, 13, 14 of Fischer's Scale.

The constants of these tables are as follows:

	Eye Colour Table	Hair Colour Table
General Refraction, Mean:	·1110 D.,	·1068 D.
,, ,, Standard Deviation:	1·5759 D.,	1·5808 D.

Correlation Ratio:

$$\eta'^2_{GR.EC} = \cdot 027{,}880, \qquad \eta'^2_{GR.HC} = \cdot 017{,}570,$$

$$\bar{\eta}^2_{GR.EC} = \cdot 006{,}726 \pm \cdot 002{,}609, \qquad \bar{\eta}^2_{GR.HC} = \cdot 006{,}726 \pm \cdot 002{,}609.$$

Thus in the case of both Eye and Hair Colour there is a small but definite association with General Refraction, the former being somewhat larger as we might anticipate. We have:

$$\eta'_{GR.EC} = \cdot 1670, \qquad \eta'_{GR.HC} = \cdot 1326.$$

In order to ascertain more clearly the nature of this association we give the array-means:

Eye Class	Mean Refraction	Hair Class	Mean Refraction
Dark Brown ...	+·4570 D. ±·1329	Black	−·1667 D. ±·1777
Medium Brown ...	−·1190 D. ±·0670	Very Dark Brown	+·0922 D. ±·0780
Light Brown ...	+·1234 D. ±·0846	Dark Brown ...	+·2291 D. ±·0690
Hazel	+·0972 D. ±·0835	Medium Brown ...	−·1010 D. ±·0661
Grey	−·0966 D. ±·0925	Light Brown ...	+·4554 D. ±·0901
Blue Grey ...	+·5426 D. ±·1096	Slatey	−·1875 D. ±·2666
Pure Blue ...	+·8750 D. ±·1941	Red	−·3750 D. ±·2850
General Population	+·1110 D. ±·0356	General Population	+·1068 D. ±·0357

The not very close relation between Eye and Hair Colours (see Vol. I, p. 23) is again evidenced by the slight accordance of greater and lesser pigmentations in the two groups with corresponding values of General Refraction. Turning first to Eye Colour we note that possibly the very dark brown eyes and almost certainly the very light (blue greys and pure blues) eyes give differentiated refraction. All indeed are differentiated towards Hypermetropia, thus confirming the results of our Refraction Class survey where we found in the extreme eye colour classes a redundancy of Hypermetropia and a deficiency of Myopia. This again points to the very dark and the very light-eyed Jews being the product of a racial intermixture. The Hair Colour arrays show very little definite association with General Refraction. The black hair, the red hair and the slatey, which might be supposed to be associated with the darkest and lightest eyes respectively, now show myopic or negative refraction, but in all cases of such small amount that with the observed numbers the negative refraction is not significant. The fact that we have 124 blue grey and pure blue eyes, but only 30 slatey and red-haired persons (see Tables on p. 219), indicates that the bulk of the light-eyed must be found in the light brown hair group, and this is confirmed by the significant differentiation in the positive sense of the refraction of this group. In the same way the very dark brown eyed class has been split up; the black-haired moiety of it tends to myopia but the other moiety must be sought in the dark brown hair groups, which exhibit a tendency to hypermetropia. We believe that something useful might be deduced from much larger statistics of ocular characters in association with pigment characters. Our data only suffice to indicate that there are interesting relations only too effectively and tantalisingly screened by an over thick veil of probable errors. Diagram 159 provides the eye colour results.

GENERAL REFRACTION & EYE COLOUR

ALIEN JEWISH BOYS

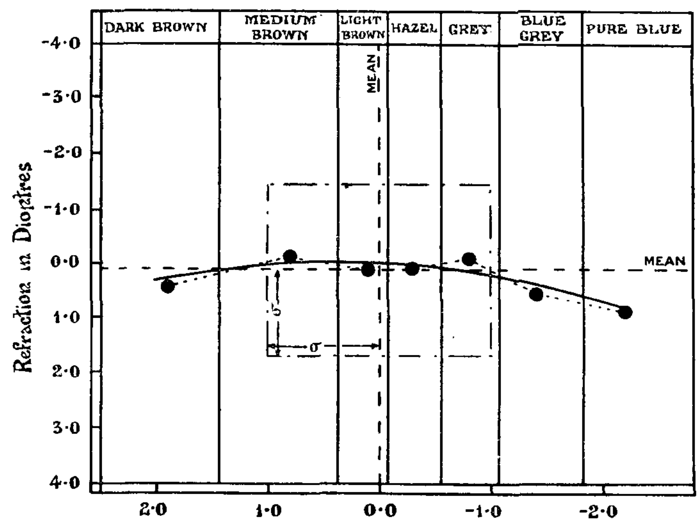

Diagram 159.

(ii) *General Refraction and the Cephalic Indices.*

(a) *General Refraction and the Cephalic Index,* $I_1 = 100\,B/L$. Our data are presented in Table CCCLXVII.

The constants of this table are as follows:

Mean: Refraction ·1065 D., Standard Deviation: Refraction 1·5798 D.

,, Cephalic Index, I_1 82·4287, ,, ,, Cephalic Index, I_1 3·5346.

Product Moment Correlation Coefficient: $r = \cdot 0311 \pm \cdot 0225$.

Correlation Ratio of Refraction on Cephalic Index is given by:

$$\eta'^2_{GR.I_1} = \cdot 015{,}526, \quad \bar{\eta}^2_{GR.I_1} = \cdot 012{,}304 \pm \cdot 003{,}516.$$

We cannot therefore assert on our data that General Refraction is in the least associated with Retzius' Cephalic Index, i.e. 100 B/L*.

* The array-mean for the 16 dolichocephalic heads 68·95–74·95 (mean 72·20) deviates most from the population mean. It is ·6562 D. ± ·5960, but this does not differ sensibly from ·1065 D. ± ·0797, the population mean. It seems unnecessary to give either graph or full array-means.

Table CCCLXVII. *General Refraction and Cephalic Index,* $I_1 = 100\ B/L$.

General Refraction in Dioptres (Central Values)

Cephalic Index, I_1 (Central Values)	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	..	−12·75	..	−15·75	Totals
69·95	—	—	—	—	1	—	1	—	—	1	2	1	—	—	—	—	—	—	—	..	—	..	—	6
71·95	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	..	—	..	—	2
73·95	—	—	—	—	1	1	—	—	4	2	—	—	—	—	—	—	—	—	—	..	—	..	—	8
75·95	—	—	—	—	—	—	1	1	6	19	4	—	2	—	1	—	—	—	—	..	—	..	—	34
77·95	—	—	1	—	3	—	1	1	24	48	8	2	2	—	2	—	—	—	—	..	—	..	—	92
79·95	—	—	2	2	2	3	4	4	34	75	13	8	3	3	—	—	3	—	2	..	1	..	1	160
81·95	1	—	1	1	3	3	7	4	27	86	22	10	3	—	1	—	4	—	1	..	—	..	—	174
83·95	—	—	—	1	5	4	5	9	41	110	11	9	11	1	1	—	—	1	1	..	—	..	—	210
85·95	—	4	—	—	2	—	6	4	31	65	12	2	2	2	2	—	—	—	—	..	—	..	—	132
87·95	—	—	—	—	—	—	6	1	10	22	6	1	—	1	1	—	—	—	—	..	—	..	—	48
89·95	—	—	—	—	—	—	—	1	3	11	3	—	2	—	—	—	—	—	—	..	—	..	—	20
91·95	—	—	—	—	—	—	—	—	6	2	—	—	—	—	—	—	—	—	—	..	—	..	—	8
Totals	1	4	4	4	17	11	31	25	186	441	82	34	25	7	8	—	7	1	4	..	1	..	1	894

(β) *General Refraction and the Cephalic Index,* $I_2 = 100\ H/L$. Table CCCLXVIII provides our data and the several constants of the table are given below.

Table CCCLXVIII. *General Refraction and the Cephalic Index,* $I_2 = 100\ H/L$.

General Refraction in Dioptres (Central Values)

Cephalic Index, I_2 (Central Values)	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	..	−12·75	..	−15·75	Totals
59·95	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	2
61·95	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	..	—	..	—	2
63·95	—	—	—	—	—	—	—	—	—	5	3	—	—	—	—	—	—	—	—	..	—	..	—	8
65·95	—	—	—	—	2	3	1	1	9	10	3	1	—	—	—	—	—	—	—	..	—	..	—	30
67·95	1	—	2	2	2	—	4	2	18	50	9	3	2	—	—	—	3	1	1	..	—	..	—	100
69·95	—	—	—	1	2	2	8	4	29	115	17	12	10	—	1	—	1	—	2	..	—	..	—	204
71·95	—	—	2	1	5	4	4	6	43	125	19	6	6	2	6	—	1	—	—	..	1	..	1	232
73·95	—	2	—	—	3	1	12	9	41	77	16	5	2	2	—	—	2	—	—	..	—	..	—	172
75·95	—	—	—	—	2	—	1	—	20	36	8	5	4	3	1	—	—	—	—	..	—	..	—	80
77·95	—	2	—	—	1	1	1	2	23	22	4	2	—	—	—	—	—	—	—	..	—	..	—	58
79·95	—	—	—	—	—	—	—	1	1	—	2	—	—	—	—	—	—	—	—	..	—	..	—	4
81·95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—
83·95	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	..	—	..	—	2
Totals	1	4	4	4	17	11	31	25	186	441	82	34	25	7	8	—	7	1	4	..	1	..	1	894

Mean: Refraction ·1065 D., Standard Deviation: Refraction 1·5798 D.

„ Cephalic Index, I_2 71·9187, „ „ Cephalic Index, I_2 3·1990.

Product Moment Correlation Coefficient: $r = \cdot 0036 \pm \cdot 0226$.

Correlation Ratio, Refraction on Cephalic Index, I_2:

$$\eta'^2_{GR.I_2} = \cdot 042{,}685, \qquad \bar{\eta}^2_{GR.I_2} = \cdot 012{,}304 \pm \cdot 003{,}516.$$

Thus, while the correlation coefficient is far less than its probable error, the correlation ratio appears to have significance. Examining the graph (Diagram 160) and the array-means it would seem that only two arrays approach significance, that for the index $I_2 = 65{\cdot}95$ is definitely significant, while that for $I_2 = 78{\cdot}26$ may possibly be so.

Grade of Cephalic Index, I_2	Mean General Refraction
62·95	$-$·1250 D. $\pm$·3076
65·95	$+$·7750 D. $\pm$·1945
67·95	$+$·1500 D. $\pm$·1066
69·95	$-$·0588 D. $\pm$·0746
71·95	$-$·0129 D. $\pm$·0700
73·95	$+$·3314 D. $\pm$·0812
75·95	$-$·1312 D. $\pm$·1191
78·26	$+$·4219 D. $\pm$·1332
General Population:	$+$·1065 D. $\pm$·0356

It is difficult to see any reason for a drop in the refraction at a special isolated value of the cephalic index, and we are inclined to believe that it is one of the fortuitous drops, which must always occur occasionally, from the mere action of random sampling, when large numbers of mean values are computed.

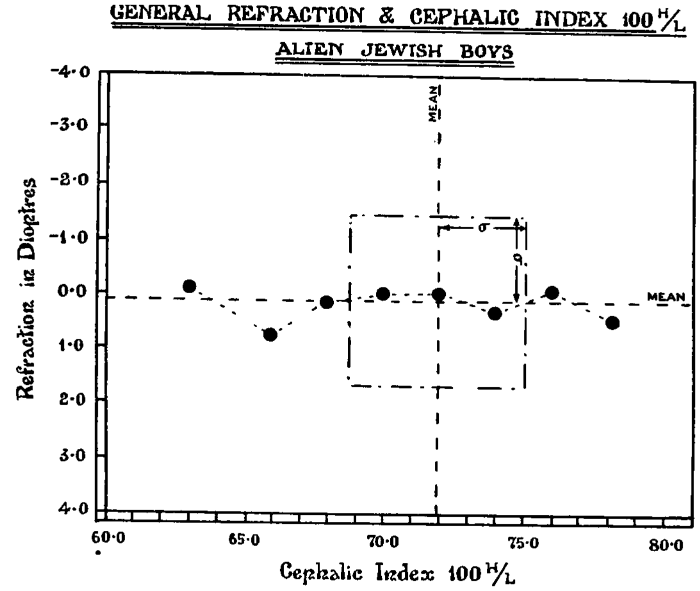

Diagram 160.

(γ) *General Refraction and Cephalic Index*, $I_3 = 100\ H/B$. Our data are given in Table CCCLXIX.

Table CCCLXIX. *General Refraction and Cephalic Index*, $I_3 = 100\ H/B$.

General Refraction in Dioptres (Central Values)

Cephalic Index, I_3 (Central Values)	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	..	−12·75	..	−15·75	Totals
75·95	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	..	—	..	—	2
77·95	—	—	—	—	1	1	—	1	1	—	—	—	—	—	—	—	—	—	—	..	—	..	—	4
79·95	—	—	—	—	—	—	2	1	14	6	4	1	1	—	—	—	—	1	—	..	—	..	—	30
81·95	—	—	—	—	—	2	3	1	16	37	11	—	2	—	2	—	—	—	—	..	—	..	—	74
83·95	1	—	1	3	2	—	6	2	17	69	7	5	5	—	—	—	1	—	1	..	—	..	—	120
85·95	—	2	1	—	4	4	9	5	37	129	13	7	6	1	1	—	3	—	—	..	—	..	—	222
87·95	—	—	—	1	2	1	2	6	26	98	13	8	1	3	1	—	—	—	2	..	—	..	—	164
89·95	—	2	2	—	4	1	6	4	36	52	20	4	5	1	2	—	3	—	—	..	1	..	1	144
91·95	—	—	—	—	2	—	2	4	17	29	7	4	3	2	2	—	—	—	—	..	—	..	—	72
93·95	—	—	—	—	1	1	1	1	14	7	6	4	1	—	—	—	—	—	—	..	—	..	—	36
95·95	—	—	—	—	—	—	—	—	4	2	—	—	—	—	—	—	—	—	—	..	—	..	—	6
97·95	—	—	—	—	1	1	—	—	4	2	1	1	—	—	—	—	—	—	—	..	—	..	—	10
99·95	—	—	—	—	—	—	—	—	2	8	1	1	1	—	—	—	—	—	1	..	—	..	—	14
Totals	1	4	4	4	17	11	31	25	188	441	83	35	25	7	8	—	7	1	4	..	1	..	1	898

Mean: General Refraction ·1052 D., Standard Deviation: General Refraction 1·5776 D.

„ Cephalic Index, I_3 87·3219, „ „ Cephalic Index, I_3 3·9273.

Product Moment Correlation Coefficient: $r = -$ ·0468 $\pm$ ·0225.

Correlation Ratio, General Refraction on Cephalic Index, I_3:

$$\eta'^2_{GR.I_3} = \cdot 018{,}510, \qquad \bar{\eta}^2_{GR.I_3} = \cdot 013{,}363 \pm \cdot 003{,}654.$$

Thus having regard to the probable error of $\bar{\eta}^2$, it is seen that there is no significant correlation ratio. Also the correlation coefficient is without significance. The regression of General Refraction

on the Cephalic Index 100 H/B is shown in Diagram 161, as it provides an excellent illustration of a zero relationship. Not a single array-mean differs significantly from the population mean, and the whole series of means shows no continuous tendency.

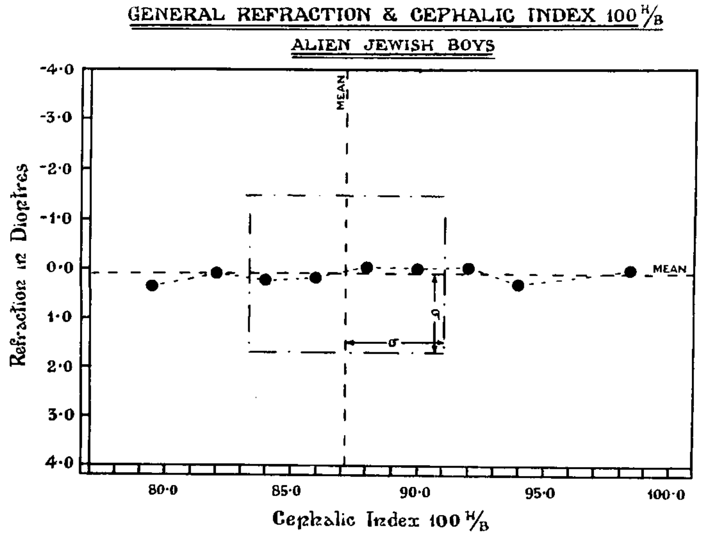

Diagram 161.

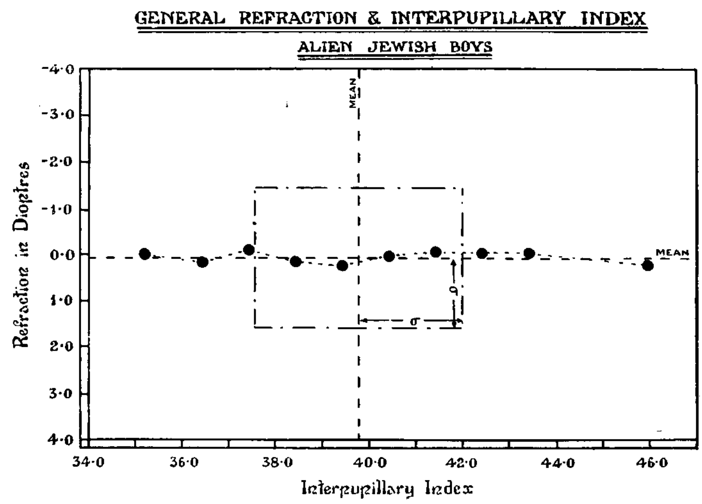

Diagram 162.

(iii) *General Refraction and Interpupillary Index.* We give the data in Table CCCLXX.

Table CCCLXX. *General Refraction and Interpupillary Index.*

General Refraction in Dioptres (Central Values)

Central Values: Interpupillary Index	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	:	−12·75	:	−15·75	Totals
34·45	—	—	—	—	—	—	—	—	2	2	—	2	—	—	—	—	—	—	—	..	—	..	—	6
35·45	—	—	—	—	—	—	—	—	9	7	—	—	1	1	—	—	—	—	—	..	—	..	—	18
36·45	—	—	—	—	1	—	4	4	10	19	3	3	1	3	—	—	—	—	—	..	—	..	—	48
37·45	—	—	—	—	—	—	3	2	26	35	17	4	3	2	2	—	—	—	—	..	—	..	—	94
38·45	—	2	—	—	2	4	2	7	43	84	14	3	2	1	2	—	2	1	1	..	—	..	—	170
39·45	1	—	1	1	1	2	9	6	35	73	15	4	4	—	2	—	2	—	—	..	—	..	—	156
40·45	—	2	—	1	3	—	5	—	20	93	13	5	4	—	2	—	1	—	1	..	—	..	—	150
41·45	—	—	2	—	2	—	4	4	15	54	5	6	4	—	—	—	—	—	—	..	1	..	1	98
42·45	—	—	—	—	3	4	—	1	9	42	3	4	—	—	—	—	2	—	2	..	—	..	—	70
43·45	—	—	1	—	1	—	—	—	7	23	7	1	4	—	—	—	—	—	—	..	—	..	—	44
44·45	—	—	—	—	2	—	—	—	2	4	—	—	—	—	—	—	—	—	—	..	—	..	—	8
45·45	—	—	—	—	—	—	—	—	2	3	1	1	1	—	—	—	—	—	—	..	—	..	—	8
46·45	—	—	—	—	—	—	—	—	4	2	—	—	—	—	—	—	—	—	—	..	—	..	—	6
47·45	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	..	—	..	—	4
48·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—
49·45	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	2
Totals	1	4	4	2	15	10	27	24	186	441	80	35	24	7	8	—	7	1	4	..	1	..	1	882

The constants of this table are as follows:

Mean: General Refraction ·0765 D., Standard Deviation: General Refraction 1·5482 D.

,, Interpupillary Index 39·8015, ,, ,, Interpupillary Index 2·2202.

Product Moment Correlation Coefficient: $r = -\cdot 0125 \pm \cdot 0227$.

Correlation Ratio, General Refraction on Interpupillary Index:

$$\eta'^2_{GR.IpI} = \cdot 014{,}264, \qquad \bar{\eta}^2_{GR.IpI} = \cdot 015{,}873 \pm \cdot 004{,}013.$$

Thus neither correlation coefficient nor ratio has any significance. Diagram 162 shows the regression of General Refraction on this Index. Not a single array-mean is significantly

different from the General Population mean. We conclude that the relative distance of the eyes apart is not a factor influencing General Refraction.

(iv) *General Refraction and Index of Sunken Eye.* The data are provided in Table CCCLXXI, and the calculated constants are given immediately below the table.

Table CCCLXXI. *General Refraction and Index of Sunken Eye.*

General Refraction in Dioptres (Central Values)

Index of Sunken Eye (Central Values)	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	..	−12·75	..	−15·75	Totals
78·45	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	2
79·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—
80·45	—	—	—	—	—	—	1	1	—	2	—	—	—	—	—	—	—	—	—	..	—	..	—	4
81·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—
82·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	1	..	1	2
83·45	—	2	—	—	—	—	2	1	3	4	1	1	—	1	1	—	—	—	—	..	—	..	—	16
84·45	—	—	—	—	—	—	1	1	6	9	5	—	2	—	—	—	—	—	—	..	—	..	—	24
85·45	1	—	1	—	—	—	—	1	5	18	6	1	1	—	—	—	—	—	—	..	—	..	—	34
86·45	—	—	—	—	—	—	3	3	18	32	1	2	1	—	—	—	—	—	—	..	—	..	—	60
87·45	—	—	—	—	1	3	5	—	16	36	6	2	4	—	—	—	—	—	1	..	—	..	—	74
88·45	—	—	2	—	2	1	5	5	40	68	11	7	1	—	—	—	2	—	—	..	—	..	—	144
89·45	—	1	—	—	5	3	6	4	27	52	6	6	2	2	1	—	1	—	—	..	—	..	—	116
90·45	—	—	1	—	1	—	3	1	19	63	12	3	4	1	2	—	1	1	—	..	—	..	—	112
91·45	—	—	—	2	5	3	2	1	20	68	19	2	3	3	—	—	2	—	—	..	—	..	—	130
92·45	—	—	—	—	—	—	2	3	12	42	8	2	3	—	2	—	—	—	—	..	—	..	—	74
93·45	—	—	—	—	1	—	—	1	9	26	7	6	2	—	2	—	—	—	—	..	—	..	—	54
94·45	—	1	—	2	2	1	—	2	7	13	1	3	2	—	—	—	—	—	—	..	—	..	—	34
95·45	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—	1	—	3	..	—	..	—	10
96·45	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	..	—	..	—	4
97·45	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	2
98·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—
99·45	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	2
Totals	1	4	4	4	17	11	31	25	188	441	83	35	25	7	8	—	7	1	4	..	1	..	1	898

Mean: General Refraction ·1052 D.

,, Index of Sunken Eye 89·6816.

Standard Deviation:

General Refraction 1·5776 D.

Index of Sunken Eye 2·8192.

Product Moment Correlation Coefficient:

$$r = -\cdot 0434 \pm \cdot 0225.$$

Correlation Ratio, General Refraction on Index of Sunken Eye:

$$\eta'^2_{GR.SEI} = \cdot 078{,}654,$$

$$\bar{\eta}^2_{GR.SEI} = \cdot 020{,}045 \pm \cdot 004{,}459.$$

Thus it would appear that the correlation coefficient is practically of no significance, but that the correlation ratio is significant, considering the value of $\bar{\eta}^2$. Accordingly there appears to be a skew regression corresponding to an $\eta'_{GR.SEI} = \cdot 2805$.

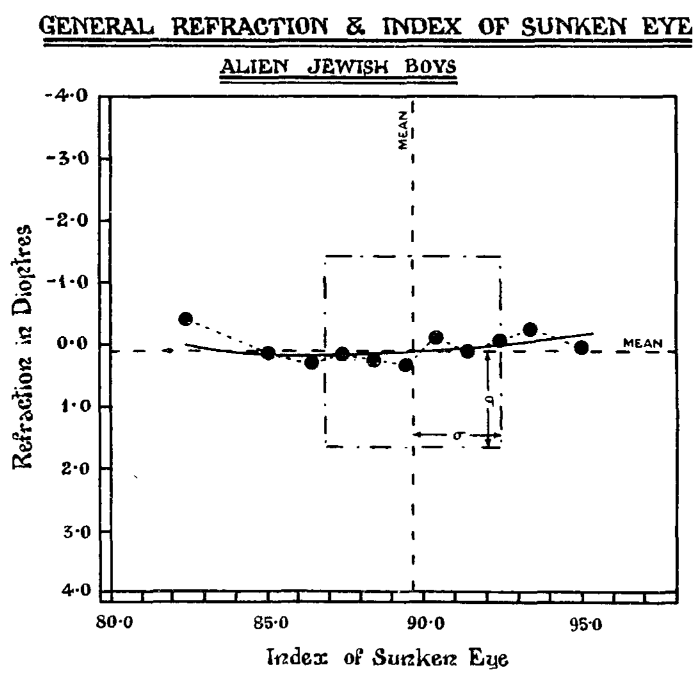

Diagram 163.

The array-means do not individually show marked deviation from the population value, but form as such things go a fairly orderly sequence,

and would seem to indicate that when the eye is either very recedent or very protuberant the General Refraction is negative or the eye myopic.

Array-Means

Grade of Index of Sunken Eye	Mean General Refraction
82·45	−·4063 D. ±·2172
85·04	+·1552 D. ±·1392
86·45	+·3125 D. ±·1374
87·45	+·1723 D. ±·1237
88·45	+·2656 D. ±·0887
89·45	+·3491 D. ±·0988
90·45	−·1138 D. ±·1005
91·45	+·1096 D. ±·0933
92·45	−·0709 D. ±·1237
93·45	−·2639 D. ±·1448
95·10	+·0577 D. ±·1476
General Population:	+·1052 D. ±·0355

Diagram 163 exhibits these results graduated with a cubic:

$$GR = \cdot 11953 - \cdot 04294\,(I - 90\cdot 45) - \cdot 004{,}744\,(I - 90\cdot 45)^2 + \cdot 000{,}2622\,(I - 90\cdot 45)^3.$$

There is clearly no marked association, but the topic might well be considered afresh with more ample data.

On the whole we must admit that General Refraction is singularly little influenced by the characters we have selected as head measurements.

(*d*) *General Astigmatism with Pigmentation and Cephalic Characters.*

(i *a* and *b*) *General Astigmatism and Eye and Hair Colours.*

Tables CCCLXXII and CCCLXXIII. *General Astigmatism and Eye and Hair Colours.*

	Eye Colours								Hair Colours							
General Astigmatism in Dioptres (Central Values)	Dark Brown	Medium Brown	Light Brown	Hazel	Grey	Blue Grey	Pure Blue	Totals	Black	V. Dark Brown	Dark Brown	Medium Brown	Light Brown	Slatey	Red	Totals
+1·50	—	—	3	—	—	—	—	3	—	—	2	1	—	—	—	3
+0·75	7	13	10	11	2	8	3	54	2	17·5	9·5	14	11	—	—	54
0·00	49	203	115	115	97	57	20	656	29	133·5	166·5	197	106	13	12	657
−0·75	6	22	19	21	18	14	3	103	3	25	36	27	9	1	1	102
−1·50	—	9	3	6	5	2	—	25	1	6	8	6	3	1	—	25
−2·25	2	2	6	9	4	7	1	31	1	3	11	12	2	1	1	31
−3·00	—	—	—	—	2	5	—	7	—	—	4	2	1	—	—	7
−3·75	—	3	—	—	4	1	1	9	—	2	2	1	4	—	—	9
−4·50	—	—	1	—	—	—	2	3	—	—	—	—	3	—	—	3
−5·25	—	—	1	—	—	—	—	1	—	—	—	—	1	—	—	1
Totals	64	252	158	162	132	94	30	892	36	187	239	260	140	16	14	892

General Astigmatism, Mean: Eye Colour − ·2388 D., Hair Colour − ·2379 D.

" " Standard Deviation: " ·7438 D., " ·7436 D.

Correlation Ratio, Astigmatism on Pigmentation:

$$\eta'^2_{GA.EC} = \cdot 027{,}078, \quad \bar{\eta}^2_{GA.EC} = \cdot 006{,}726 \pm \cdot 002{,}609,$$

$$\eta'^2_{GA.HC} = \cdot 008{,}108, \quad \bar{\eta}^2_{GA.HC} = \cdot 006{,}726 \pm \cdot 002{,}609.$$

The former is definitely significant and gives $\eta'_{GA.EC} = \cdot 1646$; the latter gives $\eta'_{GA.HC} = \cdot 0900$, but is not significant.

Light will be thrown on this matter by considering the array-means.

Eye Colour

Grade	Mean General Astigmatism
Dark Brown ...	$-\cdot0586$ D. $\pm\cdot0627$
Medium Brown ...	$-\cdot1429$ D. $\pm\cdot0316$
Light Brown ...	$-\cdot1899$ D. $\pm\cdot0399$
Hazel	$-\cdot2269$ D. $\pm\cdot0394$
Grey	$-\cdot3750$ D. $\pm\cdot0437$
Blue Grey ...	$-\cdot4468$ D. $\pm\cdot0517$
Pure Blue ...	$-\cdot5000$ D. $\pm\cdot0916$
General Population	$-\cdot2388$ D. $\pm\cdot0168$

Hair Colour

Grade	Mean General Astigmatism
Black	$-\cdot1250$ D. $\pm\cdot0836$
V. Dark Brown ...	$-\cdot1544$ D. $\pm\cdot0367$
Dark Brown ...	$-\cdot3060$ D. $\pm\cdot0324$
Medium Brown ...	$-\cdot2077$ D. $\pm\cdot0311$
Light Brown ...	$-\cdot3161$ D. $\pm\cdot0424$
Slatey	$-\cdot2812$ D. $\pm\cdot1254$
Red	$-\cdot2143$ D. $\pm\cdot1340$
General Population	$-\cdot2379$ D. $\pm\cdot0168$

These two series are most interesting from the standpoint of practical statistics. The probable errors are much of the same order except in the case of the small hair groups "Slatey" and "Red"; there are certainly more means which approach significance in the eye than the hair series, but had the eye series been in a different order of position, we might find it difficult to assert definite significance for any individual mean. As it is their positional order gives a continuous sequence, the General Astigmatism decreases continuously as we pass upwards from the pure blue to the dark brown eyes, and we feel quite confident in asserting that with the less pigment there is the more astigmatism. Representing eye colour on a normal scale we have the accompanying

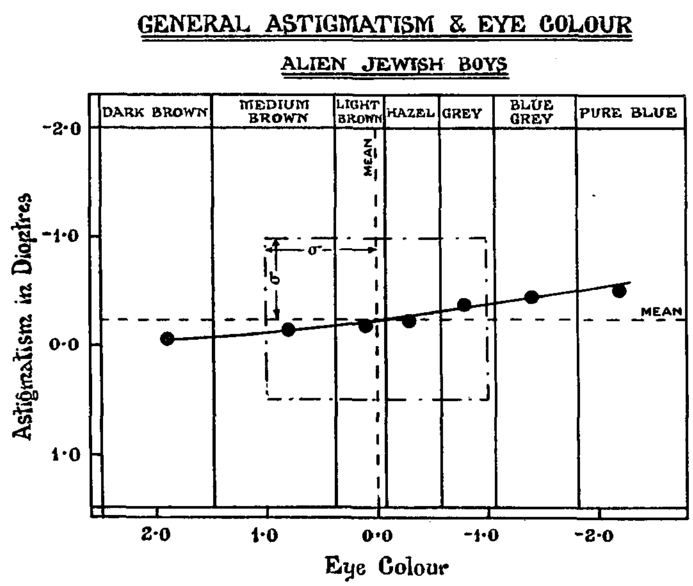

Diagram 164.

Diagram 164, where the Astigmatism has been graduated by a cubic. If as we have suggested earlier (pp. 213 and 220) the lighter eyed correspond to a blood-mixture, then the astigmatism is due to the lighter eyed. To counterbalance this we must remember that it is the darker eyed who are the more myopic. Between the lines we do see the same effect in the Hair Colour means, those for the two darkest hair groups having the least astigmatism. It is, however, impossible to arrange the hair groups on a normal scale as the amount of melanine pigment in "slatey" hair has not been tested and red hair may contain much of it, or in certain cases none at all. However, we think, the important point is demonstrated, namely that General Astigmatism is not independent of ocular pigmentation. It is not yet settled, however, whether it is generally true that the lighter haired are more astigmatic, or whether in the case of the Jews it is due to admixture with a light-haired race, having a differently constituted eye.

(ii) *General Astigmatism and the Cephalic Indices.*

(*a*) *General Astigmatism and the Cephalic Index,* $I_1 = 100\, B/L$. Table CCCLXXIV contains our data.

Table CCCLXXIV. *General Astigmatism and Cephalic Index,* $I_1 = 100\, B/L$.

Cephalic Index, 100 B/L (Central Values)

Central Values: General Astigmatism in Dioptres	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	Totals
+1·50	—	—	—	—	—	1	—	—	2	—	—	—	3
+0·75	2	—	—	5	4	13	8	15	2	5	—	—	54
0·00	2	1	6	23	68	113	137	150	104	34	15	6	659
−0·75	—	1	2	4	11	19	22	19	17	3	3	1	102
−1·50	—	—	—	2	1	5	2	10	3	—	1	1	25
−2·25	1	—	—	—	4	5	1	11	2	6	1	—	31
−3·00	—	—	—	—	4	3	—	—	—	—	—	—	7
−3·75	1	—	—	—	—	1	2	5	—	—	—	—	9
−4·50	—	—	—	—	—	—	2	—	1	—	—	—	3
−5·25	—	—	—	—	—	—	—	—	1	—	—	—	1
Totals	6	2	8	34	92	160	174	210	132	48	20	8	894

The constants of this table are:

General Astigmatism: Mean $-$ ·2374 D., Standard Deviation ·7428 D.

Cephalic Index, I_1: „ 82·4287, „ „ 3·5346.

Product Moment Correlation Coefficient: $r = -\cdot 0021 \pm \cdot 0226$.

Correlation Ratio, General Astigmatism on Index:

$$\eta'^2_{GA.I_1} = \cdot 009{,}013, \qquad \bar{\eta}^2_{GA.I_1} = \cdot 012{,}304 \pm \cdot 003{,}516.$$

Hence neither measure of association shows significance. This is confirmed by an examination of the array-means, which are plotted as a graph in Diagram 165, and indicate what an effective test the η'^2, $\bar{\eta}^2$ criterion really is.

Grade of Cephalic Index, 100 B/L	Mean General Astigmatism
72·20	−·4219 D. ±·1253
75·95	−·0662 D. ±·0859
77·95	−·3016 D. ±·0522
79·95	−·2156 D. ±·0396
81·95	−·1853 D. ±·0380
83·95	−·2929 D. ±·0346
85·95	−·2045 D. ±·0436
87·95	−·2500 D. ±·0723
90·52	−·2946 D. ±·0947
General Population:	−·2374 D. ±·0168

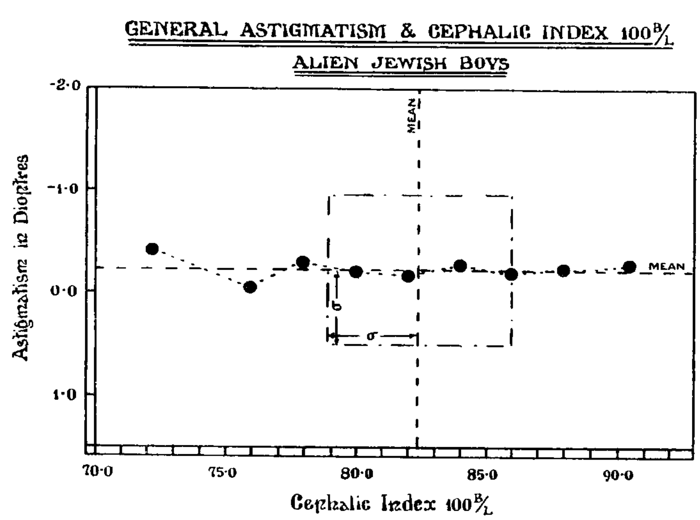

Diagram 165.

None of these means is significantly different from the population mean, and the graph indicates that the means do not form any continuous series.

(β) *General Astigmatism and the Cephalic Index,* $I_2 = 100\ H/L$. Our observations are given in Table CCCLXXV.

Table CCCLXXV. *General Astigmatism and the Cephalic Index,* $I_2 = 100\ H/L$.

Cephalic Index, 100 H/L (Central Values)

Central Values: General Astigmatism in Dioptres	59·95	61·95	63·95	65·95	67·95	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	Totals
+1·50	—	—	—	—	—	—	—	3	—	—	—	—	—	3
+0·75	—	—	3	2	5	9	17	10	4	2	2	—	—	54
0·00	2	2	3	18	62	149	182	128	66	47	—	—	—	659
−0·75	—	—	2	4	16	33	18	20	6	2	1	—	—	102
−1·50	—	—	—	2	5	8	3	3	1	1	1	—	1	25
−2·25	—	—	—	1	8	5	8	6	1	1	—	—	1	31
−3·00	—	—	—	2	1	—	3	—	—	1	—	—	—	7
−3·75	—	—	—	1	1	—	1	2	2	2	—	—	—	9
−4·50	—	—	—	—	2	—	—	—	—	1	—	—	—	3
−5·25	—	—	—	—	—	—	—	—	—	1	—	—	—	1
Totals	2	2	8	30	100	204	232	172	80	58	4	—	2	894

The constants of this table are as follows:

General Astigmatism: Mean − ·2374 D., Standard Deviation ·7428 D.

Cephalic Index, I_2: „ 71·9187, „ „ 3·1990.

Product Moment Correlation Coefficient: $r = + \cdot 0336 \pm \cdot 0226$.

Correlation Ratio, General Astigmatism on Index:

$$\eta'^2_{GA.I_2} = \cdot 042{,}942, \qquad \bar{\eta}^2_{GA.I_2} = \cdot 012{,}304 \pm \cdot 003{,}516.$$

Clearly r is non-significant, but the correlation ratio is significant, and of value $\eta'_{GA.I_2} = \cdot 2072$. The array-means are as follows and they represent a fairly orderly sequence, the first depending upon too few cases to be of any value:

Grade of Cephalic Index, 100 H/L	Mean General Astigmatism
62·95	+·0625 ± ·1446
65·95	−·5500 ± ·0915
67·95	−·4950 ± ·0501
69·95	−·2022 ± ·0351
71·95	−·1552 ± ·0329
73·95	−·1657 ± ·0382
75·95	−·1594 ± ·0560
78·26	−·4453 ± ·0626
General Population:	−·2374 ± ·0168

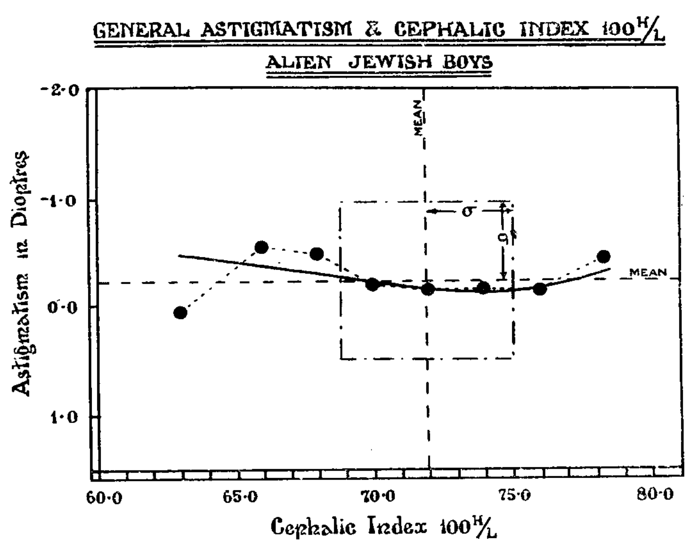

Diagram 166.

The first array is not significant, as we might expect with only 12 cases in the array. The arrays at 65·95 and 67·95, and probably those at 71·95, 75·95 and 78·26, are significant. Diagram 166 shows that the series present an orderly sequence with the minimum amount of astigmatism at the modal value of the index. We have graduated with a cubic. Without overstressing such a result, which has had its forerunners in this investigation, we can understand when good vision was essential to man's survival, how the relation of the height to length of the skull might in long ages be selected by such a factor as astigmatism in vision. In evolution it is

not needful to demonstrate that a given character has in itself selective value, it is adequate if it can be shown to be correlated with a character which undoubtedly has selective value.

(γ) *General Astigmatism and the Cephalic Index,* $I_3 = 100\,H/B$. Our data are provided in Table CCCLXXVI.

Table CCCLXXVI. *General Astigmatism and the Cephalic Index,* $I_3 = 100\,H/B$.

Cephalic Index, 100 H/B (Central Values)

General Astigmatism in Dioptres (Central Values)	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	93·95	95·95	97·95	99·95	Totals
+1·50	—	—	—	—	—	2	—	—	—	1	—	—	—	3
+0·75	2	—	2	—	5	13	4	14	7	5	1	—	1	54
0·00	—	1	20	54	93	158	131	101	56	27	5	9	7	662
−0·75	—	1	4	12	9	33	21	14	6	—	—	1	2	103
−1·50	—	2	—	2	4	8	3	4	1	—	—	—	1	25
−2·25	—	—	4	4	6	6	5	3	—	1	—	—	2	31
−3·00	—	—	—	2	—	1	—	1	2	—	—	—	1	7
−3·75	—	—	—	—	1	1	—	5	—	2	—	—	—	9
−4·50	—	—	—	—	2	—	—	1	—	—	—	—	—	3
−5·25	—	—	—	—	—	—	—	1	—	—	—	—	—	1
Totals	2	4	30	74	120	222	164	144	72	36	6	10	14	898

The constants of this table are as follows:

General Astigmatism: Mean − ·2372 D., Standard Deviation ·7414.

Cephalic Index, I_3: „ 87·3219, „ „ 3·9273.

Product Moment Correlation Coefficient: $r = +\cdot0383 \pm \cdot0225$.

Correlation Ratio, General Astigmatism on Index:

$$\eta'^2_{GA.I_3} = \cdot027{,}367, \qquad \bar{\eta}^2_{GA.I_3} = \cdot013{,}363 \pm \cdot003{,}654.$$

We have therefore an insignificant r, and a probably significant, but small, $\eta'_{GA.I_3} = \cdot1318$. If we turn to the array-means we have:

Grade of Cephalic Index, 100 H/B	Mean General Astigmatism
79·51	−·3542 D. ±·0833
81·95	−·3649 D. ±·0581
83·95	−·2938 D. ±·0456
85·95	−·2068 D. ±·0336
87·95	−·1738 D. ±·0390
89·95	−·3073 D. ±·0417
91·95	−·0938 D. ±·0589
93·95	−·1250 D. ±·0833
98·48	−·3250 D. ±·0913
General Population:	−·2372 D. ±·0167

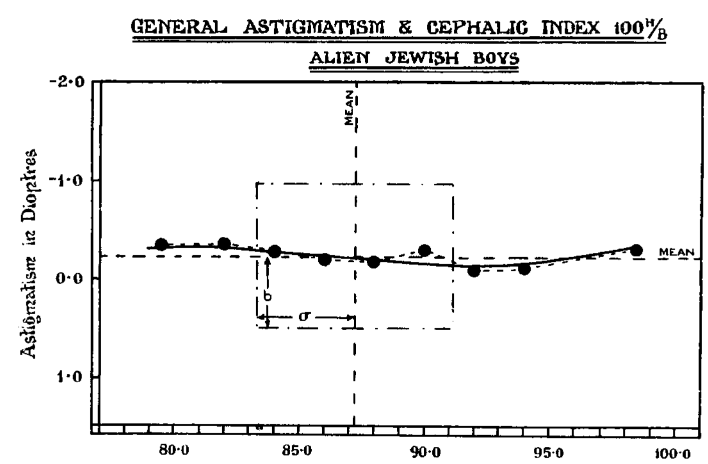

Diagram 167.

Except for the disturbing array-mean at 89·95, these form a quite orderly sequence, although none of the individual means is really significant. The effect of the index I_3 resembles that of I_2, but is only about half as intense. See Diagram 167 where the regression has again been graduated with a cubic.

(iii) *General Astigmatism and the Interpupillary Index.* The data are provided in Table CCCLXXVII.

Table CCCLXXVII. *General Astigmatism and the Interpupillary Index.*

Interpupillary Index (Central Values)

Central Values: General Astigmatism in Dioptres	34·45	35·45	36·45	37·45	38·45	39·45	40·45	41·45	42·45	43·45	44·45	45·45	46·45	47·45	48·45	49·45	Totals
+1·50	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	3
+0·75	—	2	4	6	11	10	8	5	1	4	—	3	—	—	—	—	54
0·00	6	14	35	77	126	115	115	69	53	26	4	4	6	2	—	2	654
−0·75	—	2	7	9	19	13	14	14	8	11	2	1	—	2	—	—	102
−1·50	—	—	1	—	7	2	5	5	2	2	—	—	—	—	—	—	24
−2·25	—	—	1	—	3	9	7	2	4	—	—	—	—	—	—	—	26
−3·00	—	—	—	—	2	1	—	—	1	1	2	—	—	—	—	—	7
−3·75	—	—	—	—	—	4	—	3	1	—	—	—	—	—	—	—	8
−4·50	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	3
−5·25	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Totals	6	18	48	94	170	156	150	98	70	44	8	8	6	4	—	2	882

We find for the constants of this table:

General Astigmatism: Mean − ·2219 D., Standard Deviation ·7215 D.

Interpupillary Index: „ 39·8015, „ „ 2·2202.

Product Moment Correlation Coefficient: $r = -\cdot 0964 \pm \cdot 0225$*.

Correlation Ratio, General Astigmatism on Interpupillary Index:

$$\eta'^2_{GA.IpI} = \cdot 036{,}337, \qquad \bar{\eta}^2_{GA.IpI} = \cdot 015{,}873 \pm \cdot 004{,}013.$$

Hence both measures of correlation show sensible if small association. We have

$$\eta'_{GA.IpI} = \cdot 1906,$$

indicating on comparison with r that the regression is scarcely linear. Turning to the array-means we have:

Grade of Interpupillary Index	Mean General Astigmatism
35·20	·0000 D. ±·0993
36·45	−·1250 D. ±·0702
37·45	+·0080 D. ±·0502
38·45	−·2294 D. ±·0373
39·45	−·3365 D. ±·0390
40·45	−·1750 D. ±·0397
41·45	−·3061 D. ±·0492
42·45	−·3429 D. ±·0582
43·45	−·2557 D. ±·0734
45·95	−·2679 D. ±·0920
General Population:	−·2219 D. ±·0164

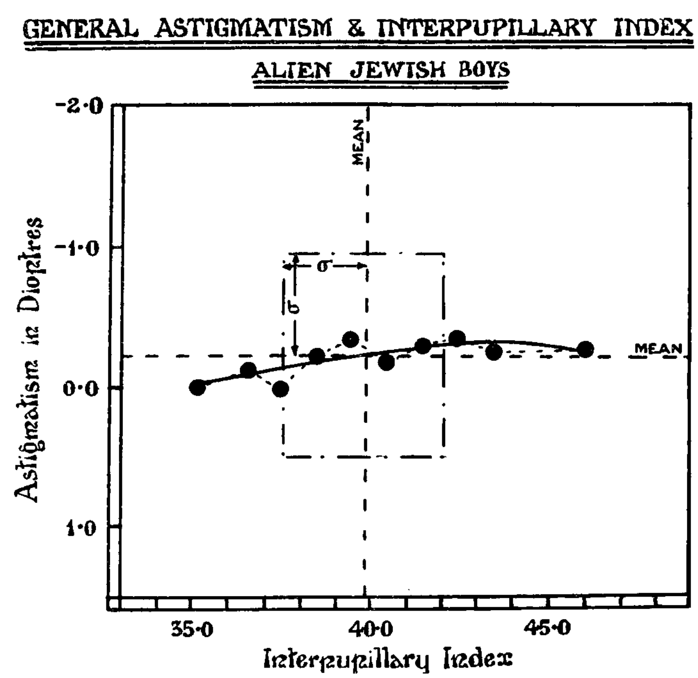

Diagram 168.

Although there is, perhaps, little significant here, beyond the mean of the array for 37·45, we see clearly that General Astigmatism increases as we increase the index, a result confirmed by

* The negative sign of the correlation arises from the negative sign of the general astigmatism, i.e. astigmatism with the rule increases with the index.

the correlation coefficient. Diagram 168 gives the regression curve which has been fitted with the cubic:

$$GA = -\cdot 22706 - \cdot 04232\,(I - 39\cdot 45) + \cdot 00287\,(I - 39\cdot 45)^2 + \cdot 000{,}447\,(I - 39\cdot 45)^3.$$

It is clear that the wider relatively the eyes are apart the greater is the astigmatism. Eyes close together have practically none.

(iv) *General Astigmatism and the Index of the Sunken Eye.* Table CCCLXXVIII gives our data.

Table CCCLXXVIII. *General Astigmatism and the Index of the Sunken Eye.*

Index of Sunken Eye (Central Values)

Central Values: General Astigmatism in Dioptres	78·45	79·45	80·45	81·45	82·45	83·45	84·45	85·45	86·45	87·45	88·45	89·45	90·45	91·45	92·45	93·45	94·45	95·45	96·45	97·45	98·45	99·45	Totals
+1·50	—	—	—	—	—	—	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	3
+0·75	—	—	—	—	—	—	3	5	3	6	5	5	6	7	4	5	4	1	—	—	—	—	54
0·00	—	—	4	—	—	12	16	22	41	55	114	82	89	98	53	42	20	7	3	2	—	2	662
−0·75	—	—	—	—	—	1	5	4	9	5	18	18	9	10	12	6	4	1	1	—	—	—	103
−1·50	1	—	—	—	1	1	—	—	4	2	4	4	3	3	2	—	—	—	—	—	—	—	25
−2·25	1	—	—	—	1	—	—	1	1	2	2	3	4	6	3	1	5	1	—	—	—	—	31
−3·00	—	—	—	—	—	—	—	—	1	2	—	—	1	2	—	—	1	—	—	—	—	—	7
−3·75	—	—	—	—	—	—	—	—	1	1	1	4	—	2	—	—	—	—	—	—	—	—	9
−4·50	—	—	—	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
−5·25	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Totals	2	—	4	—	2	16	24	34	60	74	144	116	112	130	74	54	34	10	4	2	—	2	898

The constants of this table are as follows:

General Astigmatism: Mean $-\cdot 2372$ D., Standard Deviation $\cdot 7414$ D.

Index of the Sunken Eye: „ $89\cdot 6816$, „ „ $2\cdot 8192$.

Product Moment Correlation Coefficient:

$$r = \cdot 0646 \pm \cdot 0224.$$

Correlation Ratio, General Astigmatism on Index of Sunken Eye:

$$\eta'^2_{GA.SEI} = \cdot 044{,}433,$$

$$\bar{\eta}^2_{GA.SEI} = \cdot 020{,}045 \pm \cdot 004{,}459.$$

$\eta'_{GA.SEI} = \cdot 2108$ has clearly and $r = \cdot 0646$ possibly significance, if of small intensity. Diagram 169 exhibits the fall in Astigmatism as the eye becomes more protuberant. The following table of array-means only indicates significance for the excessively recedent eyes grouped at 82·45 and for the group at 93·45. All we can assert is that markedly recedent eyes are likely to be astigmatic. After an index of 84, there is only a slight sign of further decrease in the astigmatism as the eye tends to become more protuberant.

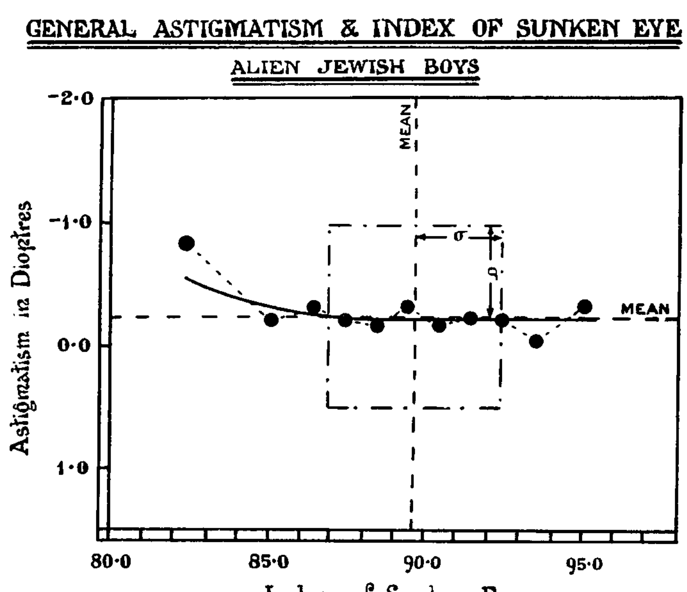

Diagram 169.

Grade of Index of Sunken Eye	Mean General Astigmatism
82·45	−·8125 D. ±·1021
85·04	−·2069 D. ±·0657
86·45	−·3250 D. ±·0646
87·45	−·2027 D. ±·0581
88·45	−·1667 D. ±·0417
89·45	−·3233 D. ±·0464
90·45	−·1674 D. ±·0472
91·45	−·2365 D. ±·0439
92·45	−·2128 D. ±·0581
93·45	−·0556 D. ±·0681
95·10	−·3317 D. ±·0693
General Population:	−·2372 D. ±·0167

Summing up our results for General Astigmatism we conclude that it is more influenced than General Refraction by both the pigmentation characters and the physical shape of the head, but that the intensity of association is not really marked. We cannot say that every one with receding eyes far apart will be markedly astigmatic, but on the average they will be more so than the General Population.

(*e*) *Corneal Refraction and Pigmentation and Cephalic Characters.* We have already drawn attention to the fact of a certain divergence between our observers *A* and *B* and our observer *C*. This leads to an average difference of slightly under the half dioptre (·42 D.) between their observations of Corneal Refraction. We have not been able to determine whether this is a personal equation effect, or was due to boys of rather worse sight being sent to the first observers. This divergence forces us to consider whether *A* and *B*'s records alone lead us to conclusions opposed to those which may be drawn from *A*, *B* and *C*'s combined data, and this involves unfortunately a great increase in the computing work.

(i *a*) *Corneal Refraction and Pigmentation of the Eye* (*Iris*). Tables CCCLXXIX and CCCLXXX (p. 234) give our distribution of Corneal Refraction for the various Eye Colours for the two series *A*, *B*, *C*, and *A*, *B*. The constants of these tables are as follows:

A, *B* and *C*

Corneal Refraction: Mean 43·4689 D.

,, ,, Standard Deviation 1·5527 D.

Correlation Ratio, Corneal Refraction on Eye Colour:

$$\eta'^2_{CR.EC} = \cdot 006{,}829, \qquad \bar{\eta}^2_{CR.EC} = \cdot 006{,}012 \pm \cdot 002{,}334.$$

A and *B* only

Corneal Refraction: Mean 43·8930 D.

,, ,, Standard Deviation 1·5198 D.

Correlation Ratio, Corneal Refraction on Eye Colour:

$$\eta'^2_{CR.EC} = \cdot 033{,}001, \qquad \bar{\eta}^2_{CR.EC} = \cdot 014{,}925 \pm \cdot 005{,}769.$$

The former gives a value $\eta'_{CR.EC} = \cdot 0827$, which is non-significant; the latter gives a significant value $\eta'_{CR.EC} = \cdot 1817$, which corrected for class-index correlation (·9717) = ·1870, the corresponding correlation coefficient being $r = \cdot 0982 \pm \cdot 0333$. This as well as the Diagram 170 indicate that the correlation is not linear. Clearly Eye Colour has little association with Corneal Refraction until we come to the grey eyes, when it suddenly falls. An examination of Diagram 170 for *A*, *B* and *C*'s combined observations shows that notwithstanding the insignificance of the correlation ratio in

their case, they give substantially the same result, i.e. a fall of the Corneal Refraction with the lighter, not distinctly Jewish eye colours. We have the following system of array-means:

Iris Colour	*A*, *B* and *C*	*A* and *B* only
Dark Brown ...	43·4464 D. ±·1252	43·8355 D. ±·1663
Medium Brown ...	43·4826 D. ±·0617	44·0759 D. ±·0969
Light Brown ...	43·6401 D. ±·0768	43·8988 D. ±·1118
Hazel	43·5337 D. ±·0785	44·2539 D. ±·1281
Grey	43·5236 D. ±·0861	43·5160 D. ±·1582
Blue Grey ...	43·1875 D. ±·1069	43·5893 D. ±·1582
Pure Blue ...	43·0469 D. ±·1851	43·2500 D. ±·2292
General Population	43·4689 D. ±·0332	43·8930 D. ±·0511

The individual means are not as significantly divergent as we might have hoped for and all we can say is: that there seems evidence, if not very strong, of a reduction in the Corneal Refraction when we take the Jewish boys with lighter irides.

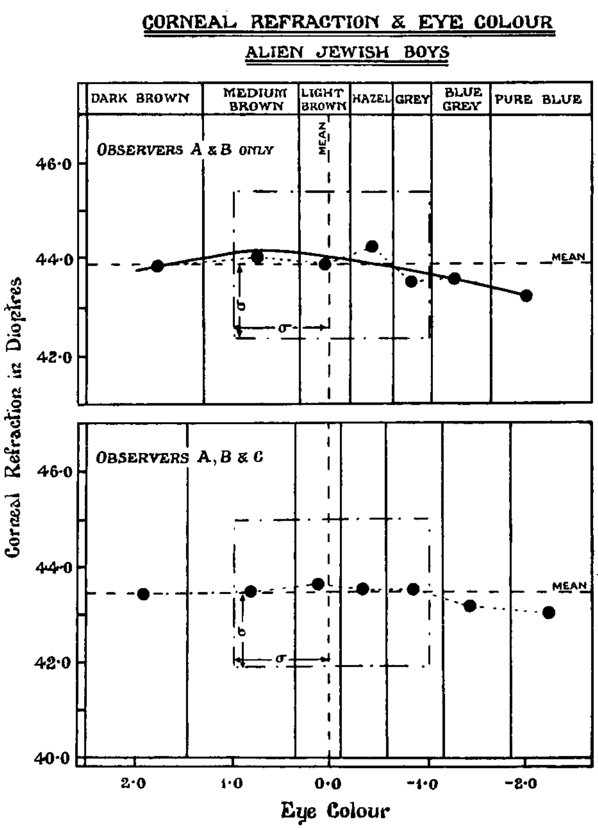

Diagram 170.

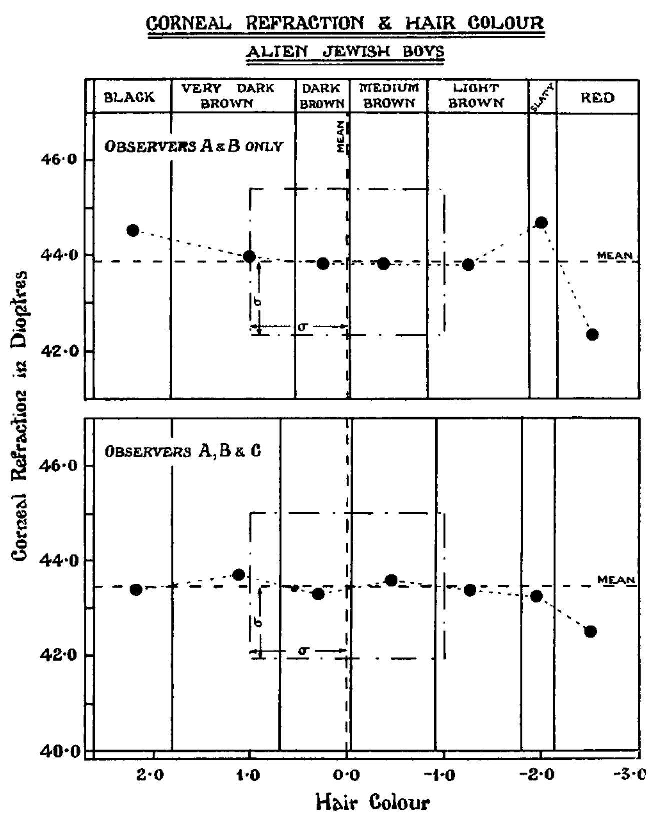

Diagram 171.

(i *b*) *Corneal Refraction and Hair Colour.* We should anticipate here that we should find the association still weaker than in the case of Eye Colour. Our data for the two series are given in Tables CCCLXXXI and CCCLXXXII (p. 235). Diagram 171 indicates that the Corneal Refraction again falls with the lighter hair shades. The erratic value for the "Slatey" hair group in the case of *A* and *B* only arises from the reduction from 20 to 6 individuals. The diagrams are plotted to a normal scale, but it must be remembered that this is only for convenience of representation.

Tables CCCLXXIX and CCCLXXX. *Corneal Refraction and Eye (Iris) Colour.*

Eye Colour

	A, *B* and *C*								*A* and *B* only							
Corneal Refraction in Dioptres (Central Values)	Dark Brown	Medium Brown	Light Brown	Hazel	Grey	Blue Grey	Pure Blue	Totals	Dark Brown	Medium Brown	Light Brown	Hazel	Grey	Blue Grey	Pure Blue	Totals
38·125	—	1	—	—	—	—	—	1	—	1	—	—	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	1	2	—	—	1	—	4	—	—	—	—	—	—	—	—
39·625	1	1	1	2	—	2	—	7	—	—	—	—	—	—	—	—
40·125	—	—	6	3	4	4	3	20	—	—	3	—	3	2	2	10
40·625	5	4	2	2	5	3	—	21	2	—	—	—	2	—	—	4
41·125	3	17	6	11	9	2	2	50	2	1	2	—	2	1	1	9
41·625	1	13	11	7	6	10	1	49	—	2	4	1	4	2	—	13
42·125	5	23	19	16	15	7	3	88	1	6	7	2	2	2	2	22
42·625	8	34	11	14	10	12	6	95	4	6	9	5	1	6	4	35
43·125	6	38	28	23	15	7	3	120	3	12	11	6	3	6	1	42
43·625	12	35	15	34	14	15	7	132	7	14	4	13	5	9	5	57
44·125	9	46	28	16	25	7	2	133	5	23	11	12	5	1	1	58
44·625	9	30	20	13	15	8	1	96	5	21	10	6	4	2	—	48
45·125	6	17	9·5	13	11	8	1	65·5	4	9	6	8	4	3	1	35
45·625	3	16	8	8	9	8	—	52	3	11	2	2	1	6	—	25
46·125	1	11	9·5	12·5	7	2	3	46	1	5	7	5·5	5	2	3	28·5
46·625	—	1	8	1·5	3	—	—	13·5	—	1	6	1·5	1	—	—	9·5
47·125	1	—	—	2	—	—	—	3	—	—	1	2	—	—	—	3
47·625	—	—	2	—	—	—	—	2	1	—	1	—	—	—	—	2
Totals	70	288	186	178	148	96	32	998	38	112	84	64	42	42	20	402

The constants of the tables for hair colour on p. 235 are as follows:

A, *B* and *C*

Corneal Refraction: Mean 43·4664 D.

" " Standard Deviation 1·5538 D.

Correlation Ratio, Corneal Refraction on Hair Colour:

$\eta'^2_{CR.HC} = \cdot 018{,}401, \quad \bar{\eta}^2_{CR.HC} = \cdot 006{,}012 \pm \cdot 002{,}334.$

$\eta'_{CR.HC} = \cdot 1357$ and is most probably significant.

A and *B* only

Corneal Refraction: Mean 43·8843 D.

" " Standard Deviation 1·5212 D.

Correlation Ratio, Corneal Refraction on Hair Colour:

$\eta'^2_{CR.HC} = \cdot 028{,}191, \quad \bar{\eta}^2_{CR.HC} = \cdot 014{,}851 \pm \cdot 005{,}735.$

$\eta'_{CR.HC} = \cdot 1679$ and is scarcely significant.

Turning to the array-means we have:

	Corneal Refraction	
Grade of Hair Colour	*A*, *B* and *C*	*A* and *B* only
Black	43·3889 D. ±·1747	44·5893 D. ±·2742
Very Dark Brown	43·6920 D. ±·0725	43·9708 D. ±·0992
Dark Brown ...	43·2855 D. ±·0637	43·8328 D. ±·1169
Medium Brown ...	43·5970 D. ±·0601	43·8347 D. ±·0921
Light Brown ...	43·3697 D. ±·0879	43·8143 D. ±·1226
Slatey	43·2250 D. ±·2343	44·7083 D. ±·4189
Red	42·4375 D. ±·2620	42·3750 D. ±·4189
General Population	43·4664 D. ±·0332	43·8843 D. ±·0511

Very few of these differences of means can be said to be significant, except that for Red Hair. None if significant is of any prognostic importance. We must content ourselves therefore by saying that the red-haired Jews are likely to have a subnormal corneal refraction.

Tables CCCLXXXI and CCCLXXXII. *Corneal Refraction and Hair Colour.*

Hair Colour

		A, *B* and *C*								*A* and *B* only							
Central Values: Corneal Refraction in Dioptres	Black	V. Dark Brown	Dark Brown	Medium Brown	Light Brown	Slatey	Red	Totals	Black	V. Dark Brown	Dark Brown	Medium Brown	Light Brown	Slatey	Red	Totals
38·125	—	—	—	1	—	—	—	1	—	—	—	1	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	3	1	—	—	4	—	—	—	—	—	—	—	—
39·625	1	2	1	—	2	1	—	7	—	—	—	—	—	—	—	—
40·125	2	2	2	8	5	—	1	20	—	—	1	6	2	—	1	10
40·625	1	4	5	6	1	1	3	21	—	2	—	1	—	—	1	4
41·125	1	9	20	8	10	1	1	50	—	2	1	1	5	—	—	9
41·625	4	9	20	9	4	2	1	49	—	3	5	4	1	—	—	13
42·125	1	16	29	26	11	2	5	90	—	9	2	7	3	1	2	24
42·625	2	20	23	32	14	3	1	95	1	13	4	12	4	1	—	35
43·125	9	22	31	38	17	2	—	119	2	7	13	13	7	—	—	42
43·625	4	21	39	41	26	—	—	131	4	11	11	16	15	—	—	57
44·125	—	38	36	37	20	2	—	133	—	19	12	15	12	—	—	58
44·625	1	16	34	33	9	1	2	96	1	11	11	17	6	—	2	48
45·125	1·5	19	20	18	5	2	—	65·5	1	11	12	7	3	1	—	35
45·625	3	16	8	20	4	—	1	52	1	9	4	8	3	—	—	25
46·125	3·5	10	2	16	10·5	3	1	46	2	5	1	11	6·5	3	—	28·5
46·625	2	3	1	6	1·5	—	—	13·5	2	3	—	3	1·5	—	—	9·5
47·125	—	2	—	—	1	—	—	3	—	1	—	1	1	—	—	3
47·625	—	—	—	2	—	—	—	2	—	1	—	1	—	—	—	2
Totals	36	209	271	304	142	20	16	998	14	107	77	124	70	6	6	404

(ii) *Corneal Refraction and the Cephalic Indices.*

(α) *Corneal Refraction and the Cephalic Index,* $I_1 = 100\,B/L$. Tables CCCLXXXIII and CCCLXXXIV contain our data for the two series of observations. The constants of the tables are as follows:

A, *B* and *C*

Corneal Refraction: Mean 43·469 D.

„ „ Standard Deviation 1·5540 D.

Cephalic Index, I_1: Mean 82·602.

„ „ Standard Deviation 3·5284.

Correlation Coefficient: $r = -\cdot 0769 \pm \cdot 0212$.

Correlation Ratio, Corneal Refraction on Index:

$$\eta'^2_{CR.I_1} = \cdot 029{,}183, \qquad \bar{\eta}^2_{CR.I_1} = \cdot 008{,}000 \pm \cdot 002{,}686.$$

A and *B* only

Corneal Refraction: Mean 43·892 D.

„ „ Standard Deviation 1·5233 D.

Cephalic Index, I_1: Mean 82·366.

„ „ Standard Deviation 3·5928.

Correlation Coefficient: $r = -\cdot 0140 \pm \cdot 0336$.

Correlation Ratio, Corneal Refraction on Index:

$$\eta'^2_{CR.I_1} = \cdot 012{,}099, \qquad \bar{\eta}^2_{CR.I_1} = \cdot 019{,}801 \pm \cdot 006{,}613.$$

Tables CCCLXXXIII and CCCLXXXIV. *Corneal Refraction and Cephalic Index*, $I_1 = 100\ B/L$.

Cephalic Index (Central Values)

A, *B* and *C*

Corneal Refraction in Dioptres (Central Values)	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	Totals
38·125	—	—	—	—	—	—	—	1	—	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	—	—	—	2	2	—	—	—	—	4
39·625	—	—	—	—	1	1	—	1	3	1	—	—	7
40·125	—	—	—	—	4	4	5	3	3	1	—	—	20
40·625	—	—	—	—	3	2	7	4	3	2	—	—	21
41·125	—	—	—	1	3	4	10	16	10	4	2	—	50
41·625	—	—	—	1	3	12	10	11	8	3	1	—	49
42·125	—	—	—	2	9	12	14	32	15	5	1	—	90
42·625	—	—	—	3	6	15	15	27	24	4	1	—	95
43·125	—	—	—	3	16	27	23	26	16	3	3	1	118
43·625	2	—	2	5	14	19	33	26	18	7	5	1	132
44·125	—	2	3	8	13	13	26	31	24	9	2	4	135
44·625	1	—	1	3	7	16	16	24	13	9	4	2	96
45·125	2	—	—	2	5·5	17	8	18	6	4	1	2	65·5
45·625	1	—	—	—	12	14	10	8	4	1	—	—	50
46·125	—	—	—	3	3·5	15	7	7	5·5	3	4	—	48
46·625	—	—	2	—	—	1	3	1	4·5	—	2	—	13·5
47·125	—	—	—	1	—	—	1	—	1	—	—	—	3
47·625	—	—	—	—	2	—	—	—	—	—	—	—	2
Totals	6	2	8	32	102	172	190	238	158	56	26	10	1000

A and *B* only

Corneal Refraction in Dioptres (Central Values)	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	Totals
38·125	—	—	—	—	—	—	—	1	—	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	—	—	—	—	—	—	—	—	—	—
39·625	—	—	—	—	—	—	—	—	—	—	—	—	—
40·125	—	—	—	—	2	2	4	—	1	1	—	—	10
40·625	—	—	—	—	1	—	3	—	—	—	—	—	4
41·125	—	—	—	1	1	2	2	3	—	—	—	—	9
41·625	—	—	—	1	2	3	3	1	2	—	1	—	13
42·125	—	—	—	1	4	1	3	6	7	1	1	—	24
42·625	—	—	—	1	4	6	2	12	7	3	—	—	35
43·125	—	—	—	2	2	9	8	10	6	2	—	1	40
43·625	2	—	2	3	6	5	11	13	9	4	1	1	57
44·125	—	2	3	2	8	7	9	16	9	3	1	—	60
44·625	—	—	1	1	5	5	9	10	10	7	—	—	48
45·125	2	—	—	—	3	5	5	11	4	3	—	2	35
45·625	—	—	—	—	4	5	7	5	2	—	—	—	23
46·125	—	—	—	3	2	7	6	5	2·5	2	3	—	30·5
46·625	—	—	2	—	—	1	3	1	1·5	—	1	—	9·5
47·125	—	—	—	—	1	—	1	—	1	—	—	—	3
47·625	—	—	—	1	1	—	—	—	—	—	—	—	2
Totals	4	2	8	16	46	58	76	94	62	26	8	4	404

The constants show us that the frequencies of *A* and *B*'s data alone are not adequate to provide a definite association, but when we have 1000 individuals, we see that $\eta'_{CR.I_1} = \cdot 1708$ is significant and also differs sensibly from a small but significant correlation coefficient. Thus the distribution is skew. This is at once confirmed by an examination of Diagram 172 lower, on p. 237, where the parabolic nature of the regression curve is clear. By the aid of this diagram we can interpret Diagram 172 upper, which shows the same type of curve only flattened. We conclude from these diagrams that deviation from the modal value of the cephalic index to any extent is associated by an increase of Corneal Refraction, which in the early stages of human evolution might affect the vision in a way detrimental to easy survival.

The array-means are as follows:

Grade of Cephalic Index, 100 *B*/*L*	Mean Corneal Refraction: *A*, *B* and *C*	Mean Corneal Refraction: *A* and *B*
72·20 (*A*, *B* and *C*) 72·52 (*A* and *B*)	44·594 D. ±·262	44·518 D. ±·275
75·95	43·906 D. ±·185	43·969 D. ±·257
77·95	43·571 D. ±·104	43·766 D. ±·151
79·95	43·695 D. ±·080	43·909 D. ±·135
81·95	43·367 D. ±·076	43·862 D. ±·118
83·95	43·255 D. ±·068	43·827 D. ±·106
85·95	43·282 D. ±·083	43·798 D. ±·130
87·95	43·384 D. ±·140	43·971 D. ±·202
90·51 (*A*, *B* and *C*) 90·62 (*A* and *B*)	44·125 D. ±·175	44·458 D. ±·297
General Population:	43·469 D. ±·033	43·892 D. ±·051

The largeness of the probable errors in the *A* and *B* series suffices to emphasise how difficult it is to discover the finer associations on a series of even 404 cases.

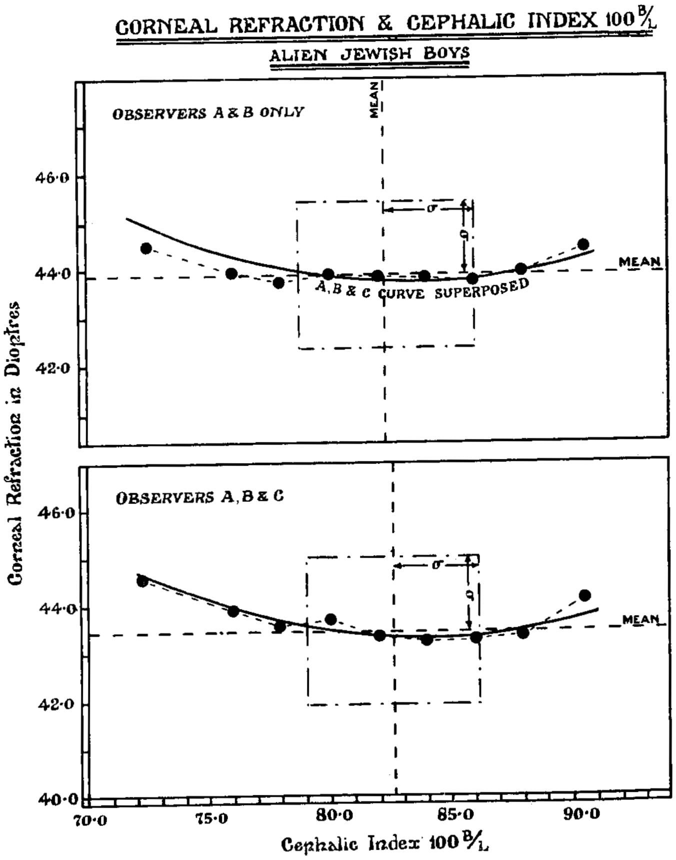

Diagram 172.

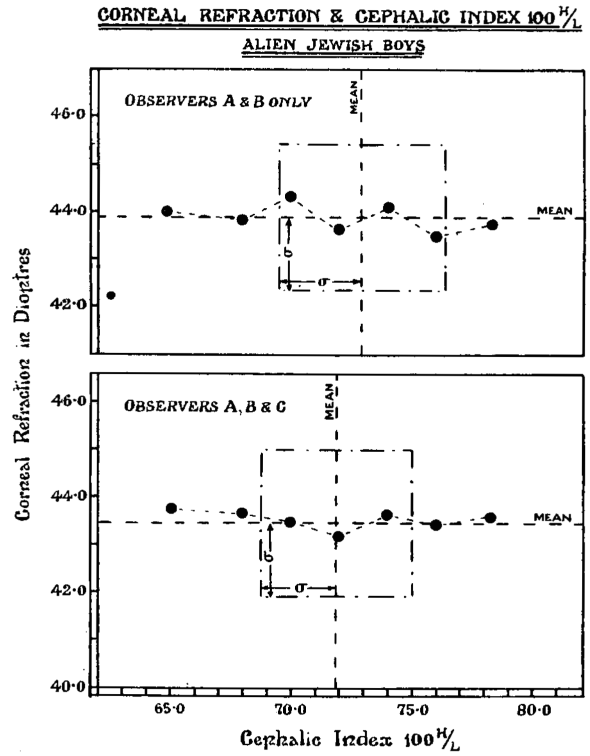

Diagram 173.

(β) *Corneal Refraction and Cephalic Index*, $I_2 = 100\ H/L$. Our data for the two series are given in Tables CCCLXXXV and CCCLXXXVI. The constants determined from these tables are:

A, *B* and *C*

Corneal Refraction:	Mean	43·468 D.
,, ,,	Standard Deviation	1·5553 D.
Cephalic Index, I_2:	Mean	71·8179.
,, ,,	Standard Deviation	3·1148.

Correlation Coefficient: $r = -\cdot 0160 \pm \cdot 0213$.

Correlation Ratio, Refraction on Index:

$$\eta'^2_{CR.I_2} = \cdot 013{,}836, \qquad \bar{\eta}^2_{CR.I_2} = \cdot 006{,}012 \pm \cdot 002{,}332.$$

r is insignificant, $\eta'_{CR.I_2} = \cdot 1176$ is probably significant.

A and *B* only

Corneal Refraction:	Mean	43·892 D.
,, ,,	Standard Deviation	1·5233 D.
Cephalic Index, I_2:	Mean	72·9005.
,, ,,	Standard Deviation	3·4626.

Correlation Coefficient: $r = -\cdot 0704 \pm \cdot 0334$.

Correlation Ratio, Refraction on Index:

$$\eta'^2_{CR.I_2} = \cdot 034{,}328, \qquad \bar{\eta}^2_{CR.I_2} = \cdot 017{,}327 \pm \cdot 006{,}192.$$

r might be just significant and $\eta'_{CR.I_2} = \cdot 1853$ possibly the same.

A study of the graphs (Diagram 173, p. 237) does not reveal more than a possibility of a slightly parabolic skew regression, with a general tendency of slender intensity to lessened Corneal Refraction with hypsicephalic values of the index. The array-means, which do not indicate any substantial differentiation, are as follows:

Grade of Cephalic Index, I_2	Mean Corneal Refraction *A*, *B* and *C*	*A* and *B* only
65·08 (*A*, *B* and *C*) 64·84 (*A* and *B*)	43·740 D. ± ·155	44·014 D. ± ·242
67·95	43·643 D. ± ·100	43·858 D. ± ·188
69·95	43·476 D. ± ·069	44·348 D. ± ·128
71·95	43·183 D. ± ·067	43·642 D. ± ·108
73·95	43·630 D. ± ·074	44·103 D. ± ·107
75·95	43·424 D. ± ·109	43·505 D. ± ·140
78·31 (*A*, *B* and *C*) 78·38 (*A* and *B*)	43·587 D. ± ·129	43·777 D. ± ·137
General Population:	43·468 D. ± ·033	43·892 D. ± ·051

Here while only the array-mean at 71·95 is significant for *A*, *B* and *C*, indicating that the fall near the modal value of the index is real, there are several possibly significant array-means for the *A* and *B* only series, but they alternate in such manner as to give no orderly sequence.

Tables CCCLXXXV and CCCLXXXVI. *Corneal Refraction and Cephalic Index*, $I_2 = 100\ H/L$.

Cephalic Index, 100 H/L (Central Values)

A, *B* and *C*

Corneal Refraction in Dioptres (Central Values)	59·95	61·95	63·95	65·95	67·95	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	Totals
38·125	—	—	—	—	—	—	—	—	—	1	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	—	—	3	—	1	—	—	—	—	—	4
39·625	—	—	—	—	—	2	1	3	1	—	—	—	—	7
40·125	—	—	—	—	3	4	6	2	4	1	—	—	—	20
40·625	—	—	—	—	1	5	8	3	3	1	—	—	—	21
41·125	—	—	—	2	4	12	19	8	5	—	—	—	—	50
41·625	—	—	—	2	5	7	17	13	3	2	—	—	—	49
42·125	—	—	—	5	11	16	33	16	7	2	—	—	—	90
42·625	—	—	—	2	12	23	22	22	8	6	—	—	—	95
43·125	—	—	—	3	8	43	26	14	9	14	1	—	—	118
43·625	—	—	2	6	16	26	32	26	14	10	—	—	—	132
44·125	2	—	4	4	14	24	33	28	12	10	—	—	2	133
44·625	—	1	1	5	12	25	15	20	10	6	1	—	—	96
45·125	—	—	1	3	9	14·5	14	15	4	3	2	—	—	65·5
45·625	—	1	—	—	6	12	12	12	5	2	—	—	—	50
46·125	—	—	1	—	8	15	7	10	6	—	1	—	—	48
46·625	—	—	1	—	—	1·5	—	9	1	—	1	—	—	13·5
47·125	—	—	—	—	1	1	1	—	—	—	—	—	—	3
47·625	—	—	—	—	—	—	2	—	—	—	—	—	—	2
Totals	2	2	10	32	110	234	248	202	92	58	6	—	2	998

A and *B* only

Corneal Refraction in Dioptres (Central Values)	59·95	61·95	63·95	65·95	67·95	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	Totals
38·125	—	—	—	—	—	—	—	—	—	1	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39·625	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40·125	—	—	—	—	1	—	4	1	3	1	—	—	—	10
40·625	—	—	—	—	—	—	3	—	1	—	—	—	—	4
41·125	—	—	—	2	1	—	5	—	1	—	—	—	—	9
41·625	—	—	—	1	—	—	5	3	3	1	—	—	—	13
42·125	—	—	—	1	3	5	2	6	6	1	—	—	—	24
42·625	—	—	—	—	3	6	7	10	5	4	—	—	—	35
43·125	—	—	—	—	2	7	8	9	4	9	1	—	—	40
43·625	—	—	—	2	6	6	11	13	9	10	—	—	—	57
44·125	2	—	—	1	4	8	15	13	5	10	—	—	2	60
44·625	—	—	1	3	4	10	8	10	5	6	1	—	—	48
45·125	—	—	1	2	1	6	10	6	4	3	2	—	—	35
45·625	—	—	—	—	—	3	6	8	4	2	—	—	—	23
46·125	—	—	1	—	4	10·5	3	7	4	—	1	—	—	30·5
46·625	—	—	1	—	—	1·5	—	6	—	—	1	—	—	9·5
47·125	—	—	—	—	—	1	2	—	—	—	—	—	—	3
47·625	—	—	—	—	1	—	1	—	—	—	—	—	—	2
Totals	2	—	4	12	30	64	90	92	54	48	6	—	2	404

It is clear that the second Cephalic Index has less relation even than the first to the curvature of the cornea.

(γ) *Corneal Refraction and Cephalic Index*, $I_3 = 100\ H/B$. Our data are presented in Tables CCCLXXXVII and CCCLXXXVIII. The constants of these tables are as follows:

A, *B* and *C*

Corneal Refraction: Mean - 43·472 D.

,, ,, Standard Deviation 1·5553 D.

Cephalic Index, I_3: Mean 87·1755.

,, ,, Standard Deviation 3·9347.

Correlation Coefficient: $r = + \cdot 0555 \pm \cdot 0212$.

Correlation Ratio, Corneal Refraction on Index:

$$\eta'^2_{CR.I_3} = \cdot 017{,}832, \qquad \bar{\eta}^2_{CR.I_3} = \cdot 007{,}984 \pm \cdot 002{,}682.$$

A and *B* only

Corneal Refraction:	Mean	43·896 D.
,, ,,	Standard Deviation	1·5297 D.
Cephalic Index, I_3:	Mean	88·6745.
,, ,,	Standard Deviation	4·6064.

Correlation Coefficient: $r = - \cdot 0612 \pm \cdot 0333$.

Correlation Ratio, Corneal Refraction on Index:

$$\eta'^2_{CR.I_3} = \cdot 056{,}324, \qquad \bar{\eta}^2_{CR.I_3} = \cdot 019{,}608 \pm \cdot 006{,}548.$$

Tables CCCLXXXVII and CCCLXXXVIII. *Corneal Refraction and Cephalic Index, $I_3 = 100\ H/B$.*

Cephalic Index, 100 *H/B* (Central Values)

A, *B* and *C*

Corneal Refraction (Central Values in Dioptres)	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	93·95	95·95	97·95	99·95	Totals
38·125	—	—	—	—	—	—	—	—	—	1	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	1	1	1	—	1	—	—	—	—	—	4
39·625	—	—	—	—	2	4	—	—	1	—	—	—	—	7
40·125	—	—	—	1	4	4	3	3	1	3	—	—	1	20
40·625	—	—	—	1	3	5	6	1	2	3	—	—	—	21
41·125	—	—	3	7	8	15	10	4	1	2	—	—	—	50
41·625	—	—	2	5	7	14	9	4	3	4	—	—	1	49
42·125	—	2	4	10	15	24	16	12	6	—	—	—	1	90
42·625	—	—	11	8	12	25	8	18	5	5	2	—	1	95
43·125	—	—	1	8	20	18	31	18	14	4	3	3	—	120
43·625	1	—	1	10	21	35	14	29	16	2	1	1	1	132
44·125	1	1	5	12	22	30	20	21	7	8	—	2	4	133
44·625	—	1	4	15	10	25	21	8	5	4	—	2	1	96
45·125	—	—	1	2	11	17	19	3·5	8	4	—	—	—	65·5
45·625	—	—	1	4	1	12	7	9	14	—	—	—	4	52
46·125	—	—	3	3·5	6	15	6	11·5	3	—	—	—	—	48
46·625	—	—	1	0·5	3	3	1	3	—	—	—	2	—	13·5
47·125	—	—	1	—	—	1	1	—	—	—	—	—	—	3
47·625	—	—	—	—	—	—	—	—	2	—	—	—	—	2
Totals	2	4	38	88	146	248	172	146	88	40	6	10	14	1002

A and *B* only

Corneal Refraction (Central Values in Dioptres)	76·95	78·95	80·95	82·95	84·95	86·95	88·95	90·95	92·95	94·95	96·95	98·95	Totals
38·125	—	—	—	—	—	—	—	—	1	—	—	—	1
38·625	—	—	—	—	—	—	—	—	—	—	—	—	—
39·125	—	—	—	—	—	—	—	—	—	—	—	—	—
39·625	—	—	—	—	—	—	—	—	—	—	—	—	—
40·125	—	—	—	3	—	—	2	1	3	—	—	1	10
40·625	—	—	—	—	—	2	—	1	1	—	—	—	4
41·125	—	2	—	1	—	1	3	—	2	—	—	—	9
41·625	—	1	1	1	2	1	—	2	4	—	—	1	13
42·125	2	1	3	2	2	4	6	3	—	—	—	1	24
42·625	—	4	2	4	4	2	10	2	4	2	—	1	35
43·125	—	—	1	6	2	6	11	9	3	3	1	—	42
43·625	—	—	3	5	11	4	18	11	2	1	1	1	57
44·125	1	3	2	3	11	9	11	6	8	—	2	4	60
44·625	1	1	7	6	11	9	4	2	4	—	2	1	48
45·125	—	—	1	8	7	6	2	7	4	—	—	—	35
45·625	—	—	1	1	3	2	5	9	—	—	—	4	25
46·125	—	2	2·5	4	8	2	9	3	—	—	—	—	30·5
46·625	—	1	0·5	—	2	1	3	—	—	—	2	—	9·5
47·125	—	1	—	—	1	—	—	1	—	—	—	—	3
47·625	—	—	—	—	—	1	—	1	—	—	—	—	2
Totals	4	16	24	44	64	50	84	58	36	6	8	14	408

While the correlation coefficients are barely significant, the correlation ratio of Corneal Refraction on Cephalic Index I_3 is significant in the two cases and we have for *A*, *B* and *C*: $\eta'_{CR.I_3} = \cdot 1335$ and for *A*, *B* only: $\eta'_{CR.I_3} = \cdot 2373$, the correlation being weakened by the addition of *C*'s results. We will now examine the array-means with a view to tracing this matter further.

A, *B* and *C*

Cephalic Index, 100 *H/B*	Mean Corneal Refraction
79·59	43·489 ± ·158 D.
81·95	43·361 ± ·112 D.
83·95	43·279 ± ·087 D.
85·95	43·442 ± ·067 D.
87·95	43·485 ± ·080 D.
89·95	43·615 ± ·089 D.
91·95	43·864 ± ·112 D.
93·95	42·850 ± ·166 D.
98·48	43·858 ± ·192 D.
General Population:	43·472 ± ·033 D.

A and *B* only

Cephalic Index, 100 *H/B*	Mean Corneal Refraction
79·55	43·625 ± ·231 D.
81·95	44·052 ± ·211 D.
83·95	43·773 ± ·156 D.
85·95	44·414 ± ·129 D.
87·95	43·965 ± ·146 D.
89·95	43·804 ± ·113 D.
91·95	44·090 ± ·135 D.
93·95	42·972 ± ·172 D.
98·52	43·911 ± ·195 D.
General Population:	43·896 ± ·051 D.

It will be seen at once that the only significant differences from the General Population mean occur in arrays at 91·95 and 93·95 for the A, B and C series and in arrays at 85·95 and 93·95 for A and B only. It is probable accordingly that we can only stress the dip at 93·95 (see Diagram 174). Apart from this dip there is no regularity in the distribution of array-means. The suggestion must be that very high values of the Index tend to be associated with low Corneal Refraction (although this is not confirmed by the array at 98·5, where the numbers in both series are, however, small). It may be that high values of the Index are due to a racial intermixture. Anyhow the nature of the association as indicated by the graph is not such as to be of any service for prediction.

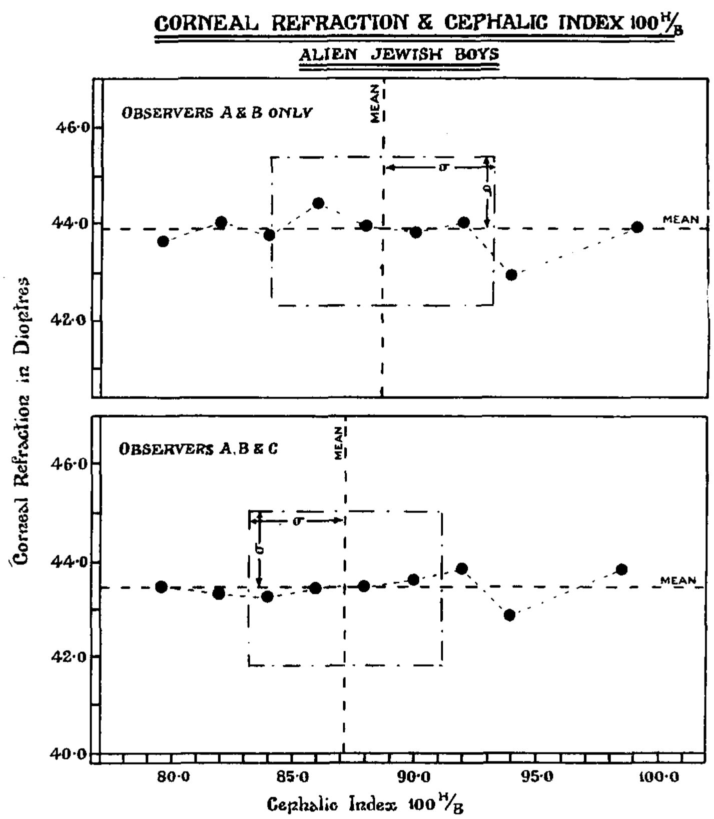

Diagram 174.

At this point in our work, it seemed worth while inquiring what relation such an ocular character as Corneal Refraction had to an *absolute* measurement on the head. We have seen (Vol. II, p. 132) that for the ages 6 to 15 of the boys there is no sensible change of Corneal Refraction with growth. But the absolute size of the head does vary with growth. Growth cannot therefore be a common factor giving an association between the radius of curvature of the cornea and any measure of size of head. The most suggestive size measure to take seemed to be the distance from the auricular axis to the centre of the left eyeball, i.e. the length we have termed c (see Vol. II, p. 118), which may be defined as the auricular-corneal length. The following correlation table was then obtained:

Table CCCLXXXIX. *Corneal Refraction and Auricular-Corneal Length.*

Corneal Refraction in Dioptres (Central Values)

Auricular-Corneal Distance in mm. (Central Values)	38·0	38·5	39·0	39·5	40·0	40·5	41·0	41·5	42·0	42·5	43·0	43·5	44·0	44·5	45·0	45·5	46·0	46·5	47·0	47·5	Totals
66·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
68·5	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	2
70·5	—	—	—	—	—	—	—	—	—	—	—	—	2	2	2	—	—	—	—	—	6
72·5	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	2
74·5	—	—	—	1	1	2	1	1	1	4	3	3	4	—	1	1	1	—	—	—	24
76·5	—	—	—	—	1	1	2	1	4	7	3	7	6	4	7	2	9	3	1	—	58
78·5	—	—	1	1	2	—	3	4	5	7	8	2	4	12	7	3	8	—	1	—	68
80·5	—	—	—	1	4	2	6	7	16	19	20	21	29	15	12	10	7	1	—	2	172
82·5	—	—	—	—	7	2	7	8	13	18	24	27	25	13	10·5	9	11	2·5	1	—	178
84·5	1	—	—	2	2	5	11	5	15	12	22	24	19	11	7	8	6	2	—	—	152
86·5	—	—	3	2	1	6	8	2	9	12	13	13	16	15	6	5	1	—	—	—	112
88·5	—	—	—	—	2	1	5	10	10	6	12	15	13	8	4	8	2	2	—	—	98
90·5	—	—	—	—	—	2	4	6	9	5	6	11	9	2	3	1	—	—	—	—	58
92·5	—	—	—	—	—	—	2	2	3	1	—	2	3	10	2	3	—	—	—	—	28
94·5	—	—	—	—	—	—	1	3	2	2	3	4	1	2	—	—	2	—	—	—	20
96·5	—	—	—	—	—	—	—	—	1	1	3	3	—	—	—	—	1	1	—	—	10
98·5	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	2	—	—	4
100·5	—	—	—	—	—	—	—	—	—	—	—	—	2	2	2	2	—	—	—	—	8
102·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
104·5	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	2
Totals	1	—	4	7	20	21	50	49	90	95	120	132	135	96	65·5	52	48	13·5	3	2	1004

The constants of this table are as follows:

Auricular-Corneal Distance: Mean 83·9024, Standard Deviation 5·1784.
Corneal Refraction: „ 43·5228, „ „ 1·5539.
Product Moment Coefficient of Correlation: $r = -\cdot 0529 \pm \cdot 0212$.

Correlation Ratio of Corneal Refraction on Auricular Corneal Distance:

$$\eta'^2_{CR.AcD} = \cdot 047{,}839, \quad \bar{\eta}^2_{CR.AcD} = \cdot 018{,}924 \pm \cdot 003{,}519.$$

Here the correlation coefficient is insignificant, if it be not actually non-significant, but the correlation ratio is significant and we have $\eta'_{CR.AcD} = \cdot 2187$. We turn to a graph for enlightenment (see Diagram 175) and note that from the array at 78·5 to that at 90·5 there is a fairly smooth and uniform decrease of Corneal Refraction with increase of Auricular-Corneal Distance. But for the two arrays at either end of the range there is a divergence from linearity, the Corneal Refraction tending to fall for values of the Auricular-Corneal distance less than 78·5, and to rise for values greater than 90·5. Are these results merely apparent and due to the vagaries of random sampling with outlying small frequencies? Let us examine the array-means for the answer.

Grade of Auricular-Corneal Distance in mm.	Mean Corneal Refraction in Dioptres
69·83	43·583 ±·303
74·50	42·917 ±·214
76·50	44·116 ±·138
78·50	43·691 ±·127
80·50	43·567 ±·080
82·50	43·537 ±·079
84·50	43·293 ±·085
86·50	43·138 ±·099
88·50	43·401 ±·106
90·50	42·996 ±·138
93·33	43·594 ±·151
98·83	44·354 ±·214
General Population:	43·523 ±·033

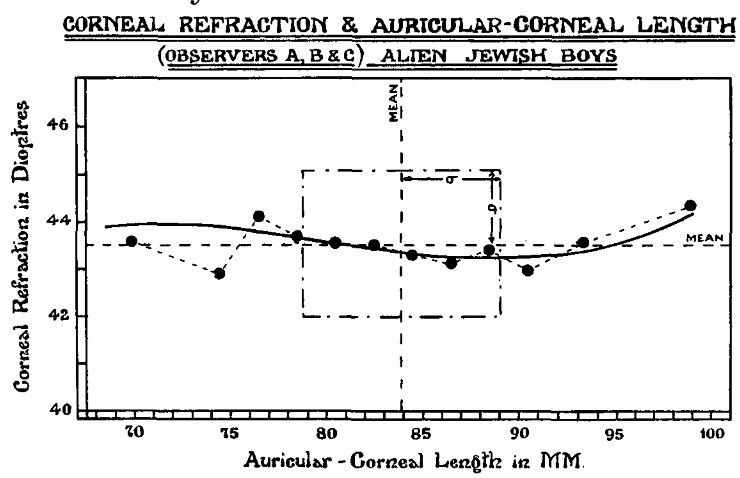

Diagram 175.

It will be seen that the array-means at 74·5, 90·5 and 98·83 differ significantly from the General Population mean, and the significance is the greater because they diverge in a sense opposite to the direction suggested by the regression line as determined from the observations at 78·5 to 90·5. It would seem therefore that these divergences are not merely results of random sampling. It has struck us repeatedly in this work that occurrences in the tail values of various characters present peculiarities which deserve to be pursued further. As a rule tail frequencies are small and their eccentricities within the limits of random sampling, but when they are significant and anomalous, they may be most suggestive for evolutionary interpretation or as indications of racial admixtures. We have graduated the array-means with a cubic.

(iii) *Corneal Refraction and Interpupillary Index.* Our data will be found in Tables CCCXC and CCCXCI, pp. 242–3. The constants are as follows:

		A, *B* and *C*	*A* and *B* only
Corneal Refraction:	Mean	43·463 D.	43·884 D.
„ „	Standard Deviation	1·5581 D.	1·5256 D.
Interpupillary Index:	Mean	39·825	39·052
„ „	Standard Deviation	2·1835	2·3195
Product Moment Coefficient of Correlation:		$r = -\cdot 0951 \pm \cdot 0213$	$r = -\cdot 0023 \pm \cdot 0336$

Correlation Ratio of Corneal Refraction on Interpupillary Index:

For A, B and C $\quad \eta'^2_{CR.IpI} = \cdot 026{,}165, \quad \bar{\eta}^2_{CR.IpI} = \cdot 009{,}128 \pm \cdot 002{,}889.$

For A and B only $\quad \eta'^2_{CR.IpI} = \cdot 081{,}518, \quad \bar{\eta}^2_{CR.IpI} = \cdot 032{,}338 \pm \cdot 008{,}407.$

Both r's are negative but that for A and B's observations only is not significant, while that for A, B and C's is significant but small. On the other hand the correlation ratios for both series are significant and give $\eta'_{CR.IpI} = \cdot 1618$ and $\cdot 2855$ respectively. Diagram 176 by no means indicates very close relationships, but certainly corresponds to non-linear regression. The array-means are as follows:

Grade of Interpupillary Index	Mean Corneal Refraction: A, B and C	Mean Corneal Refraction: A and B only
35·22	44·077 ±·206 D.	44·526 ±·243 D.
36·45	43·548 ±·146 D.	43·837 ±·163 D.
37·45	43·782 ±·104 D.	43·804 ±·123 D.
38·45	43·731 ±·077 D.	44·255 ±·106 D.
39·45	43·267 ±·080 D.	43·247 ±·120 D.
40·45	43·224 ±·078 D.	43·615 ±·143 D.
41·45	43·524 ±·098 D.	(41·85) 44·304 ±·194 D.
42·45	43·294 ±·122 D.	
43·45	43·035 ±·149 D.	(45·30) 44·279 ±·202 D.
45·85	43·542 ±·192 D.	
General Population:	43·463 ±·033 D.	43·884 ±·051 D.

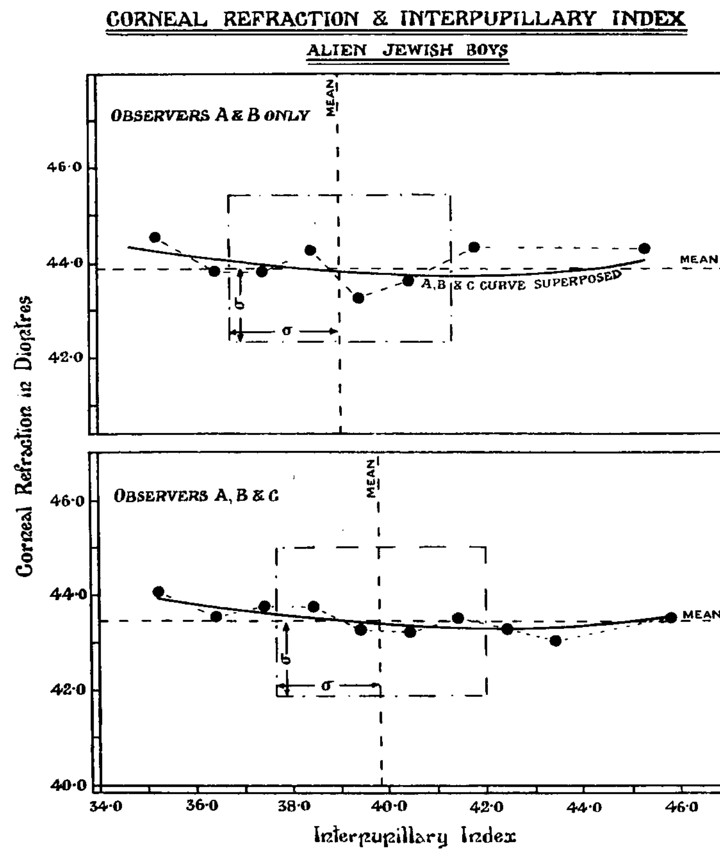

Diagram 176.

It is clear that a number of the means are here significantly different from that of the general population, although fewer in the second than in the first series owing to the inadequacy of the numbers. We have fitted the first series with the cubic

$$CR = 43\cdot 125 + \cdot 23340 - \cdot 06689\,(I - 40\cdot 45) + \cdot 01285\,(I - 40\cdot 45)^2 + \cdot 00108\,(I - 40\cdot 45)^3$$

and transferred this to the modified mean in the diagram for the second series. We believe it probable that the relative distance of the eyes apart does affect the Corneal Refraction if only in a minor degree.

Table CCCXC. *Corneal Refraction and the Interpupillary Index, A, B and C.*

Corneal Refraction in Dioptres (Central Values)

Interpupillary Index (Central Values)	38·125	38·625	39·125	39·625	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	47·625	Totals
34·45	—	—	2	—	—	—	—	—	—	1	—	1	—	—	—	1	0·5	0·5	—	—	6
35·45	—	—	—	—	—	—	—	—	—	1	1	3	5	1	7	1	1	—	—	—	20
36·45	—	—	—	—	2	—	1	2	5	6	5	10	4	8	6	2	1	—	—	—	52
37·45	—	—	—	—	1	1	1	4	13	17	8	10	14	8	4	5	12	3	1	—	102
38·45	—	—	—	2	1	3	9	5	12	28	15	20	22	25	12·5	15	9·5	2	1	2	184
39·45	1	—	—	1	6	4	6	13	16	10	29	25	28	11	7	6	8	1	—	—	172
40·45	—	—	1	2	4	3	13	14	17	11	27	22	28	19	12	3	4	2	—	—	182
41·45	—	—	—	1	1	3	11	8	5	6	14	10	16	14	12	8	4	1	—	—	114
42·45	—	—	—	1	3	2	4	1	11	4	9	17	6	5	—	7	2	2	—	—	74
43·45	—	—	1	—	2	4	2	1	8	7	6	7	3	1	1	1	3	2	1	—	50
44·45	—	—	—	—	—	1	—	1	2	2	—	—	1	—	1	1	1	—	—	—	10
45·45	—	—	—	—	—	—	—	—	—	2	—	3	1	—	2	—	—	—	—	—	8
46·45	—	—	—	—	—	—	2	—	—	—	1	1	2	—	—	—	—	—	—	—	6
47·45	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	2	—	—	—	—	4
48·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49·45	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	2
Totals	1	—	4	7	20	21	49	49	89	95	117	129	132	92	64·5	52	46	13·5	3	2	986

We give the similar table for the observations of A and B only.

Table CCCXCI. *Corneal Refraction and the Interpupillary Index, A and B only.*

Corneal Refraction in Dioptres (Central Values)

Central Values: Inter-pupillary Index	38·125	:	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	47·625	Totals
34·45	—	..	—	—	—	—	—	1	—	1	—	—	—	1	0·5	0·5	—	—	4
35·45	—	..	—	—	—	—	—	—	—	3	3	1	7	—	—	—	—	—	14
36·45	—	..	1	—	—	1	4	2	3	10	4	6	6	2	1	—	—	—	40
37·45	—	..	1	—	—	3	11	10	4	8	8	8	4	4	6	2	1	—	70
38·45	—	..	—	—	3	1	4	13	7	9	8	18	8	10	8	2	2	1	94
39·45	1	..	6	2	1	4	2	3	19	11	13	3	1	2	5	1	—	—	74
40·45	—	..	2	2	2	3	1	2	4	8	14	8	2	—	2	2	—	—	52
41·45	—	..	—	—	3	—	1	1	1	1	3	—	4	1	3	—	—	—	18
42·45	—	..	—	—	—	—	—	—	—	3	1	2	—	2	—	2	—	—	10
43·45	—	..	—	—	—	1	1	1	1	—	1	1	1	1	3	—	—	1	12
44·45	—	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
45·45	—	..	—	—	—	—	—	2	—	—	—	—	2	—	—	—	—	—	4
46·45	—	..	—	—	—	—	—	—	1	1	2	—	—	—	—	—	—	—	4
47·45	—	..	—	—	—	—	—	—	—	—	2	—	—	2	—	—	—	—	4
48·45	—	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49·45	—	..	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	2
Totals	1	..	10	4	9	13	24	35	42	55	59	47	35	25	28·5	9·5	3	2	402

(iv) *Corneal Refraction and Index of Sunken Eye.* Our data for the two series are given in Tables CCCXCII and CCCXCIII. The constants of these tables are the following:

		A, B and C	A and B only
Corneal Refraction:	Mean	43·4760 D.	43·9064 D.
,, ,,	Standard Deviation	1·5538 D.	1·5176 D.
Index of Sunken Eye:	Mean	89·2773	89·4894
,, ,,	Standard Deviation	2·8504	3·2139
Product Moment Correlation Coefficient:		$r = -\cdot 0081 \pm \cdot 0213$	$r = +\cdot 0490 \pm \cdot 0334$

Correlation Ratio of Corneal Refraction on Index:

For A, B and C $\quad \eta'^2_{CR.SEI} = \cdot 015{,}177, \quad \bar{\eta}^2_{CR.SEI} = \cdot 010{,}978 \pm \cdot 003{,}140.$

For A and B only $\quad \eta'^2_{CR.SEI} = \cdot 023{,}581, \quad \bar{\eta}^2_{CR.SEI} = \cdot 024{,}631 \pm \cdot 007{,}340.$

Both the Correlation Coefficient and the Correlation Ratio are non-significant. Under these circumstances it was probably hardly worth while to examine the array-means, but we give them.

A, *B* and *C*

Grade of Index of Sunken Eye	Mean Corneal Refraction
85·05	43·290 ± ·206 D.
86·05	43·627 ± ·135 D.
87·45	43·663 ± ·129 D.
88·45	43·588 ± ·116 D.
89·45	43·524 ± ·083 D.
90·45	43·545 ± ·091 D.
91·45	43·085 ± ·094 D.
92·45	43·416 ± ·087 D.
93·45	43·389 ± ·122 D.
94·45	43·353 ± ·131 D.
97·45	43·771 ± ·214 D.
General Population:	43·476 ± ·033 D.

A and *B* only

Grade of Index of Sunken Eye	Mean Corneal Refraction
83·12	43·823 ± ·209 D.
85·45	44·580 ± ·218 D.
86·45	43·967 ± ·166 D.
87·45	43·833 ± ·148 D.
88·45	43·969 ± ·128 D.
89·45	44·139 ± ·171 D.
90·45	43·559 ± ·166 D.
91·45	43·969 ± ·148 D.
92·45	43·875 ± ·209 D.
93·45	43·867 ± ·181 D.
95·575	43·531 ± ·181 D.
General Population:	43·906 ± ·051 D.

Only two of the whole series of means seem to differ significantly from the general population values, namely the mean of the array at 91·45 for A, B, C and that at 85·45 for A and B only.

We do not think any stress can be laid on these deviations. The graphs (not published) do not suggest any orderly sequence, and we conclude that a protuberant eye is not a factor substantially modifying the Corneal Refraction.

The following are the tables for this correlation.

Table CCCXCII. *Corneal Refraction and Index of Sunken Eye* (*A*, *B* and *C*).

Corneal Refraction in Dioptres (Central Values)

Central Values

Index of Sunken Eye	38·125	38·625	39·125	39·625	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	47·625	Totals
78·45	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	2
79·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
80·45	—	—	—	—	—	—	—	—	—	—	1	1	—	1	1	—	—	—	—	—	4
81·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
82·45	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	2
83·45	—	—	1	1	—	1	1	—	—	5	—	1	4	—	4	—	—	—	—	—	18
84·45	—	—	—	—	1	—	2	1	5	2	2	7	1	1	—	—	1	1	—	—	24
85·45	—	—	—	1	1	1	1	2	—	—	2	8	6	2	4	—	6	—	2	—	36
86·45	—	—	—	—	1	1	2	6	7	7	4	9	7	7	3	5	5	—	—	2	66
87·45	—	—	—	—	3	2	2	4	3	6	16	14	12	5	2	4	8	1	—	—	82
88·45	—	—	2	1	5	2	8	6	11	15	18	17	19	22	16	7	7	2	—	—	158
89·45	—	—	—	2	2	5	6	2	13	17	15	11	18	13	6	10	9	3	—	—	132
90·45	—	—	—	—	3	2	7	14	17	13	19	13	11	10	6·5	7	1·5	—	—	—	124
91·45	—	—	1	2	2	4	9	8	15	12	16	17	21	9	10	10	6	3	1	—	146
92·45	—	—	—	—	—	2	10	1	4	3	10	13	15	7	6	3	—	—	—	—	74
93·45	—	—	—	—	2	1	—	2	8	5	6	11	8	6	2	5	4·5	3·5	—	—	64
94·45	1	—	—	—	—	—	2	2	3	4	7	9	10	6	2	—	—	—	—	—	46
95·45	—	—	—	—	—	—	—	—	2	1	2	1	2	4	—	—	—	—	—	—	12
96·45	—	—	—	—	—	—	—	—	—	2	—	—	—	2	1	1	—	—	—	—	6
97·45	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	2
98·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
99·45	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	2
Totals	1	—	4	7	20	21	50	48	89	95	120	132	135	96	65·5	52	48	13·5	3	2	1002

The corresponding table for *A* and *B* only is:

Table CCCXCIII. *Corneal Refraction and Index of Sunken Eye* (*A and B only*).

Corneal Refraction in Dioptres (Central Values)

Central Values

Index of Sunken Eye	38·125	..	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	47·625	Totals
78·45	—	..	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	2
79·45	—	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
80·45	—	..	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	2
81·45	—	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
82·45	—	..	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	2
83·45	—	..	—	—	—	—	—	2	—	—	2	—	4	—	—	—	—	—	8
84·45	—	..	—	—	—	1	2	—	—	4	—	1	—	—	1	1	—	—	10
85·45	—	..	1	—	1	—	—	—	1	5	3	1	2	—	6	—	2	—	22
86·45	—	..	1	—	1	3	5	3	1	4	4	3	3	3	5	—	—	2	38
87·45	—	..	3	2	—	1	1	3	7	5	9	5	2	3	6	1	—	—	48
88·45	—	..	2	1	2	1	—	6	8	4	11	14	7	3	4	1	—	—	64
89·45	—	..	—	—	1	—	3	4	6	6	1	3	—	5	4	3	—	—	36
90·45	—	..	—	—	—	3	6	5	6	4	—	5	5	4	—	—	—	—	38
91·45	—	..	1	—	2	2	1	3	5	10	7	3	5	4	3	1	1	—	48
92·45	—	..	—	—	—	—	1	1	2	7	9	2	2	—	—	—	—	—	24
93·45	—	..	2	1	—	1	3	1	—	6	6	4	2	2	1·5	2·5	—	—	32
94·45	1	..	—	—	2	—	—	4	3	1	5	2	—	—	—	—	—	—	18
95·45	—	..	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	4
96·45	—	..	—	—	—	—	—	—	—	—	—	2	1	1	—	—	—	—	4
97·45	—	..	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	2
98·45	—	..	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
99·45	—	..	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	2
Totals	1	..	10	4	9	12	23	35	42	57	60	48	35	25	30·5	9·5	3	2	406

(*f*) *Corneal Astigmatism and Pigmentation and Cephalic Characters.*

(i) *Corneal Astigmatism and Pigmentation.*

(*a*) *Eye Colour* (*Iris*) *and Corneal Astigmatism.* Our data for the *A*, *B*, *C* and *A*, *B* only series are contained in Tables CCCXCIV and CCCXCV, p. 246. The constants are as follows:

	A, *B* and *C*	*A* and *B* only
Corneal Astigmatism: Mean	·6192 D.	·7687 D.
,, ,, Standard Deviation	·8611 D.	·9524 D.
Product Moment Correlation Coefficient:	$r = -\cdot0764 \pm \cdot0212$	$r = -\cdot1762 \pm \cdot0326$

Correlation Ratio of Corneal Astigmatism on Eye (Iris) Colour:

For *A*, *B* and *C* $\eta'^2_{CA.EC} = \cdot030{,}822$, $\bar{\eta}^2_{CA.EC} = \cdot006{,}012 \pm \cdot002{,}334$.

For *A* and *B* only $\eta'^2_{CA.EC} = \cdot044{,}376$, $\bar{\eta}^2_{CA.EC} = \cdot014{,}925 \pm \cdot005{,}769$.

Clearly the coefficients of correlation, if they differ somewhat in the two series, are both significant and *negative*. The correlation ratios are also significant and lead after correction for class-index* to:

$$\eta_{CA.EC} = \cdot1806 \text{ for } A, B, C,$$

and $$= \cdot2167 \text{ for } A \text{ and } B \text{ only.}$$

It will be seen at once that it is the lightest eyes which have the most astigmatism. The regression is not truly linear, although its trend might be approximately represented by a straight line (see Diagram 177). The array-means are provided below:

Grade of Eye Colour (Iris) (Martin's Scale)	Mean Corneal Astigmatism *A*, *B* and *C*	*A* and *B* only
Dark Brown ...	·5250 ± ·0694 D.	·4737 ± ·1042 D.
Medium Brown ...	·5313 ± ·0342 D.	·6429 ± ·0607 D.
Light Brown ...	·6169 ± ·0426 D.	·8571 ± ·0701 D.
Hazel	·5435 ± ·0435 D.	·6797 ± ·0803 D.
Grey	·5980 ± ·0477 D.	·9107 ± ·0991 D.
Blue Grey ...	·9844 ± ·0593 D.	·8750 ± ·0991 D.
Pure Blue ...	1·0547 ± ·0866 D.	1·4250 ± ·1436 D.
General Population	·6192 ± ·0184 D.	·7687 ± ·0320 D.

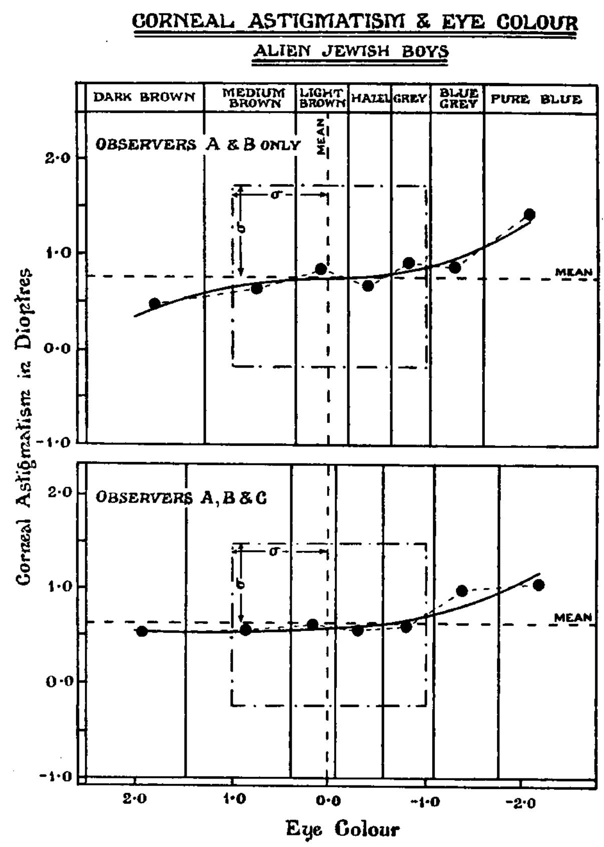

Diagram 177.

Whichever series we settle to judge from there cannot be a doubt that the eyes with less iris pigmentation have greater Corneal Astigmatism. This confirms what we have previously noted on the assumption that the light-eyed Jews have less racial purity than the dark-eyed, namely that increased astigmatism may be due to racial intermixture, or to want of fit in diverse racial components. The question whether astigmatism is greater in human racial hybrids than in men of purer race is worthy of a special study.

* Using class-index correlation as found for the eye colour distribution under visual acuity (footnote, p. 202), i.e. $r_C = \cdot9722$, on the basis of a normal distribution for iris pigmentation.

Tables CCCXCIV and CCCXCV. *Corneal Astigmatism and Eye (Iris) Colour.*

Corneal Astigmatism in Dioptres (Central Values)

Eye (Iris) Colour	*A, B* and *C*													*A* and *B* only										
	−2·25	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	+6·00	Totals	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	Totals
Dark Brown	—	—	4	23	36	4	3	—	—	—	—	—	70	—	4	10	21	2	1	—	—	—	—	38
Medium Brown	—	1	3	128	124	15	15	—	2	—	—	—	288	1	3	29	65	8	5	—	1	—	—	112
Light Brown	—	3	1·5	77	72·5	19	8	3	—	—	2	—	186	2	1	21	41	8	6	3	—	—	2	84
Hazel	1	1	8	84	54	15	11	1	—	1	1	1	178	—	6	21	22	7	7	—	—	—	1	64
Grey	—	2	—	72	49	11	8	4	1	1	—	—	148	2	—	10	20	2	4	2	1	1	—	42
Blue Grey	—	—	1	30	40	7	5	9	3	—	1	—	96	—	1	10	22	5	—	2	2	—	—	42
Pure Blue	—	—	1	12	8	4	2	2	2	1	—	—	32	—	1	4	7	1	2	2	2	1	—	20
Totals	1	7	18·5	426	383·5	75	52	19	8	3	4	1	998	5	16	105	198	33	25	9	6	2	3	402

(β) *Corneal Astigmatism and Hair Colour.* The Hair Colour data presented in Tables CCCXCVI and CCCXCVII show the same results as for Eye Colour, only with less intensity. The addition of *C*'s observations to those of *A* and *B* tends to blur the association. This may be due to the larger number of Slatey and Red Hair children which fell to *C*'s lot. With regard to Red Hair we believe as far as melanine pigment is concerned it ought to stand on the average above Light Brown. The position of Slatey Hair is difficult to decide, and we have suggested that it arises possibly from a Lithuanian intermixture.

Tables CCCXCVI and CCCXCVII. *Corneal Astigmatism and Hair Colour.*

Corneal Astigmatism in Dioptres (Central Values)

Hair Colour Fischer's Scale[1]	*A, B* and *C*													*A* and *B* only										
	−2·25	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	+6·00	Totals	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	Totals
Slatey	—	1	1	8	7	2	1	—	—	—	—	—	20	—	1	—	4	1	—	—	—	—	—	6
Black	—	—	0·5	14	16·5	4	—	1	—	—	—	—	36	—	—	4	7	2	—	1	—	—	—	14
V. Dark Brown	—	—	9	88	85	14	11	—	1	—	1	—	209	—	9	34	49	7	7	—	1	—	—	107
Dark Brown	1	3	1	118	98	24	14	10	1	1	—	—	271	2	1	17	44	6	2	5	—	—	—	77
Medium Brown	—	3	3	139	115	20	14	5	4	—	—	1	304	3	3	33	57	12	11	2	3	—	—	124
Red	—	—	—	8	4	—	4	—	—	—	—	—	16	—	—	2	2	—	2	—	—	—	—	6
Light Brown	—	—	4	53	57	10	8	3	2	2	3	—	142	—	2	17	35	5	3	1	2	2	3	70
Totals	1	7	18·5	428	382·5	74	52	19	8	3	4	1	998	5	16	107	198	33	25	9	6	2	3	404

[1] For the numbers on Fischer's scale corresponding to the terminology see p. 201 above.

The constants of these tables are as follows:

		A, B and *C*	*A* and *B* only
Corneal Astigmatism:	Mean	·6170 D.	·7649 D.
,, ,,	Standard Deviation	·8611 D.	·9353 D.

The difficulty as to the order of pigmentation intensity with regard to Slatey and Red Hair rather precludes a just appreciation of the correlation coefficient. We are inclined to believe that there are more granules in the Slatey hairs than their macroscopic appearance would suggest. If we include them in the darker hair group and Red in the lighter we should have the following tetrachoric tables:

Hair	A, B, C Corneal Astigmatism			A, B Corneal Astigmatism		
	0·00 and under	+ 0·75 and over	Totals	0·00 and under	+ 0·75 and over	Totals
Dark Shades	244·5	291·5	536	68	136	204
Light Shades	210	252	462	60	140	200
Totals	454·5	543·5	998	128	276	404

These give for the tetrachoric coefficients of correlation:

$$r_t = -\cdot 0025 \pm \cdot 0337 \text{ for } A, B, C, \qquad r_t = -\cdot 0587 \pm \cdot 0548 \text{ for } A \text{ and } B;$$

both of these are non-significant, indicating that a crude grouping here will not aid us. Another and we think less legitimate scale order gave from the equations to the regression line

$$\text{Product Moment Coefficient: } r = -\cdot 0558 \pm \cdot 0213 \text{ for } A, B \text{ and } C,$$

$$\text{,,} \quad \text{,,} \quad \text{,,} \quad = -\cdot 1359 \pm \cdot 0328 \text{ for } A \text{ and } B,$$

the lesser pigmentation being associated with the greater astigmatism.

Next we turned to the correlation ratios. We found:

$$\text{For } A, B \text{ and } C \quad \eta'^2_{CA.HC} = \cdot 010{,}709, \quad \bar{\eta}^2_{CA.HC} = \cdot 006{,}012 \pm \cdot 002{,}334.$$

$$\text{For } A \text{ and } B \text{ only} \quad \eta'^2_{CA.HC} = \cdot 030{,}285, \quad \bar{\eta}^2_{CA.HC} = \cdot 014{,}851 \pm \cdot 005{,}735.$$

In the former case the value of $\eta'^2_{CA.HC}$ is scarcely significant; in the latter it probably just reaches significance. Turning to the array-means for elucidation we have:

Grade of Hair Colour	Corneal Astigmatism A, B and C	Corneal Astigmatism A and B only
Slatey	·4125 ± ·1299 D.	·6250 ± ·2575 D.
Black	·5833 ± ·0968 D.	·8036 ± ·1686 D.
Very Dark Brown	·5347 ± ·0402 D.	·5607 ± ·0610 D.
Dark Brown ...	·6338 ± ·0353 D.	·7500 ± ·0719 D.
Medium Brown ...	·5822 ± ·0333 D.	·7742 ± ·0567 D.
Red	·7500 ± ·1452 D.	1·0000 ± ·2575 D.
Light Brown ...	·8028 ± ·0487 D.	1·0607 ± ·0754 D.
General Population	·6170 ± ·0184 D.	·7649 ± ·0314 D.

Here the mean for Light Brown hair differs significantly from that for the General Population in both series, the only other possibly significant array-mean being that in the A, B series for Very Dark Brown. The fact is that the data are inadequate to show, having regard to the probable errors, such small differences in the Corneal Astigmatism as may exist. Still if we omit Slatey and absolute Black as probably resulting from racial admixture and place Red above Light Brown, we see a steady, if slight, increase of Corneal Astigmatism as the Hair Colour lessens in intensity. This is illustrated in the accompanying Diagram 178 for A and B's data, where the remaining hair shades have been reduced to a normal scale. The corresponding correlation coefficient is $r = -\cdot 1788 \pm \cdot 0332$. Without being dogmatic we think it probable that lighter hair is associated with greater Corneal

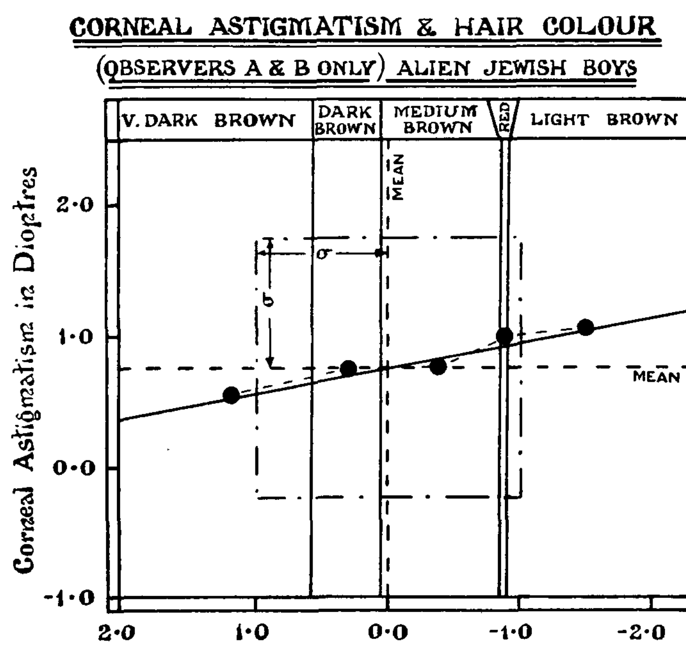

Diagram 178.

Astigmatism, although the evidence for greater astigmatism with lighter pigmentation is more obvious in the colour of iris than in the colour of hair.

(ii) *Corneal Astigmatism and the Cephalic Indices.*

(*a*) *Corneal Astigmatism and the Cephalic Index,* $I_1 = 100\,B/L$. Our data will be found in Tables CCCXCVIII and CCCXCIX.

Tables CCCXCVIII and CCCXCIX. *Corneal Astigmatism and the Cephalic Index,* $I_1 = 100\,B/L$.

Cephalic Index (Central Values)

A, B and C

Corneal Astigmatism in Dioptres (Central Values)	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	Totals
− 2·25	—	—	—	—	—	—	1	—	—	—	—	—	1
− 1·50	—	—	—	—	1	1	1	—	2	—	2	—	7
− 0·75	—	—	—	1	1·5	2	4	6	3	1	—	—	18·5
0·00	3	1	1	16	35	87	78	103	68	22	13	1	428
+ 0·75	1	1	7	13	47·5	60	78	83	58	24	4	7	383·5
+ 1·50	—	—	—	1	5	12	11	24	15	3	3	1	75
+ 2·25	—	—	—	1	6	4	11	14	8	3	4	1	52
+ 3·00	1	—	—	—	4	4	2	5	1	2	—	—	19
+ 3·75	1	—	—	—	2	—	1	2	1	1	—	—	8
+ 4·50	—	—	—	—	—	1	1	1	—	—	—	—	3
+ 5·25	—	—	—	—	—	1	1	—	2	—	—	—	4
+ 6·00	—	—	—	—	—	—	1	—	—	—	—	—	1
Totals	6	2	8	32	102	172	190	238	158	56	26	10	1000

A and B only

Corneal Astigmatism in Dioptres (Central Values)	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	Totals
− 2·25	—	—	—	—	—	—	—	—	—	—	—	—	—
− 1·50	—	—	—	—	1	—	—	—	2	—	2	—	5
− 0·75	—	—	—	1	1	2	4	5	2	1	—	—	16
0·00	1	1	1	5	8	22	17	19	22	10	1	—	107
+ 0·75	1	1	7	8	28	26	41	44	24	13	1	4	198
+ 1·50	—	—	—	1	2	4	4	12	9	—	1	—	33
+ 2·25	—	—	—	1	4	2	5	9	1	—	3	—	25
+ 3·00	1	—	—	—	—	2	2	2	—	2	—	—	9
+ 3·75	1	—	—	—	2	—	1	2	—	—	—	—	6
+ 4·50	—	—	—	—	—	—	1	1	—	—	—	—	2
+ 5·25	—	—	—	—	—	—	1	—	2	—	—	—	3
+ 6·00	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	4	2	8	16	46	58	76	94	62	26	8	4	404

The constants of these tables are as follows:

		A, B and *C*	*A* and *B* only
Corneal Astigmatism:	Mean	·6180 D.	·7649 D.
,, ,,	Standard Deviation	·8606 D.	·9353 D.
Cephalic Index, 100 B/L:	Mean	82·6020	82·3658
,, ,,	Standard Deviation	3·5284	3·5928
Product Moment Correlation Coefficient:		$r = +\cdot 0071 \pm \cdot 0213$	$r = +\cdot 0345 \pm \cdot 0335$

Correlation Ratio, Corneal Astigmatism on Index:

For *A*, *B* and *C* $\eta'^2_{CA.I_1} = \cdot 004{,}179$,

$\bar{\eta}^2_{CA.I_1} = \cdot 007{,}000 \pm \cdot 002{,}514$.

For *A* and *B* only $\eta'^2_{CA.I_1} = \cdot 013{,}871$,

$\bar{\eta}^2_{CA.I_1} = \cdot 019{,}801 \pm \cdot 006{,}613$.

Accordingly judged by our correlation test we find no association whatever between Corneal Astigmatism and the ratio of breadth to length of the head. We do not think it needful to give the array-means, but in Diagram 179 the reader will find their graph for *A*, *B* and *C*'s data. We do this the more readily because such a graph really differs essentially from those in Diagrams 180 and 183, which suggest that there actually is some relationship to be unravelled.

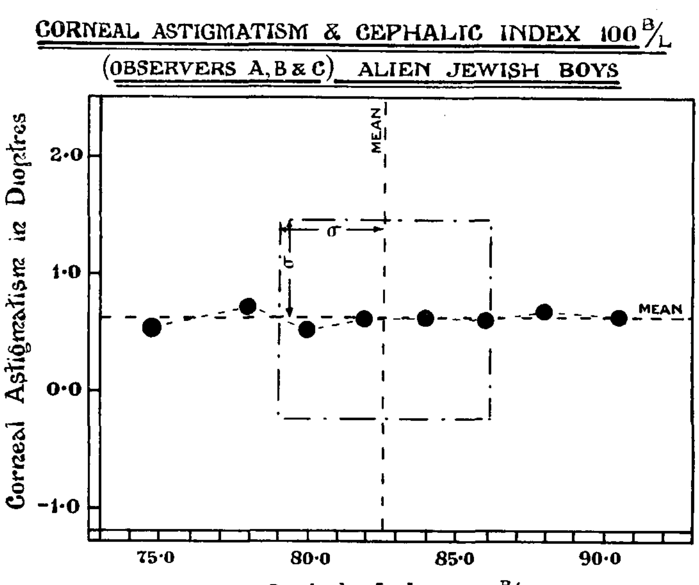

Diagram 179.

(β) *Corneal Astigmatism and the Cephalic Index*, $I_2 = 100\,H/L$. Our data for both series are given in Tables CD and CDI. The constants of these series are as follows:

		A, *B* and *C*	*A* and *B* only
Corneal Astigmatism:	Mean	·6177 D.	·7649 D.
,, ,,	Standard Deviation	·8615 D.	·9353 D.
Cephalic Index, $I_2 = 100\,H/L$:	Mean	71·9179	72·9005
,, ,,	Standard Deviation	3·1148	3·4626
Product Moment Correlation Coefficient:		$r = +\cdot0432 \pm \cdot0213$	$r = -\cdot0044 \pm \cdot0336$

It is accordingly clear that if there be any association the regression is not linear. We now proceed to the correlation ratio and find:

Tables CD and CDI. *Corneal Astigmatism and Cephalic Index*, $I_2 = 100\,H/L$.

Cephalic Index 100 *H*/*L* (Central Values)

A, *B* and *C*

Central Values: Corneal Astigmatism in Dioptres	59·95	61·95	63·95	65·95	67·95	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	Totals
−2·25	—	—	—	—	—	1	—	—	—	—	—	—	—	1
−1·50	—	—	—	—	—	2	—	2	3	—	—	—	—	7
−0·75	—	—	1	—	2	2·5	5	5	1	2	—	—	—	18·5
0·00	1	2	2	13	46	100	119	90	35	19	1	—	—	428
+0·75	1	—	6	13	36	99·5	92	73	34	25	2	—	—	381·5
+1·50	—	—	—	1	11	17	19	12	8	4	1	—	2	75
+2·25	—	—	1	1	9	10	8	12	8	2	1	—	—	52
+3·00	—	—	—	3	2	1	4	6	—	2	1	—	—	19
+3·75	—	—	—	1	1	—	1	2	1	2	—	—	—	8
+4·50	—	—	—	—	2	—	—	—	1	—	—	—	—	3
+5·25	—	—	—	—	1	—	—	—	1	2	—	—	—	4
+6·00	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Totals	2	2	10	32	110	234	248	202	92	58	6	—	2	998

A and *B* only

Central Values: Corneal Astigmatism in Dioptres	59·95	61·95	63·95	65·95	67·95	69·95	71·95	73·95	75·95	77·95	79·95	81·95	83·95	Totals
−2·25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
−1·50	—	—	—	—	—	—	—	2	3	—	—	—	—	5
−0·75	—	—	1	—	1	2	5	4	1	2	—	—	—	16
0·00	1	—	1	1	8	10	23	32	16	14	1	—	—	107
+0·75	1	—	1	5	10	46	49	40	24	20	2	—	—	198
+1·50	—	—	—	1	4	3	7	9	2	4	1	—	2	33
+2·25	—	—	1	1	5	3	5	2	5	2	1	—	—	25
+3·00	—	—	—	3	—	—	—	3	—	2	1	—	—	9
+3·75	—	—	—	1	1	—	1	—	1	2	—	—	—	6
+4·50	—	—	—	—	1	—	—	—	1	—	—	—	—	2
+5·25	—	—	—	—	—	—	—	—	1	2	—	—	—	3
+6·00	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	2	—	4	12	30	64	90	92	54	48	6	—	2	404

Correlation Ratio of Corneal Astigmatism on Index:

For *A*, *B* and *C* $\quad \eta'^2_{CA.I_2} = \cdot021{,}715, \quad \bar{\eta}^2_{CA.I_2} = \cdot006{,}012 \pm \cdot002{,}332.$

For *A* and *B* only $\quad \eta'^2_{CA.I_2} = \cdot053{,}142, \quad \bar{\eta}^2_{CA.I_2} = \cdot017{,}327 \pm \cdot006{,}192.$

We see accordingly that the association, if small ($\eta'_{CA.I_2} = \cdot1474$ and $\cdot2305$ respectively), is quite significant, although reduced and somewhat obscured as in several other instances by adding *C*'s observations to those of *A* and *B*. Both series, however, show the same feature, namely, that the astigmatism increases (with the rule) as we depart from the modal value of the index. In other words if in early times astigmatism had selective value there would be a small force tending to maintain the racial value of the cephalic index. Such evolutionary "forces" have several times been unearthed in the course of the present memoir, and suggest that we may have to seek at some distance from a given character the factor by the selection of which it has been moulded. No one, so far as we are aware, has yet suggested that acuity of vision may be a factor which moulds the shape of the cranium, but it appears to us that it may well have helped in this direction, and that we must not seek necessarily for direct selection of any character in an

organism. Its evolutionary value may lie indirectly in the manner in which it assists or impedes some much more important sensory or physiological process.

Diagram 180 shows the nature of the regression. The array-means are as follows:

A, *B* and *C*

Grade of Index, 100 H/L	Mean Corneal Astigmatism
65·08	·7174 ± ·0857 D.
67·95	·7841 ± ·0554 D.
69·95	·5321 ± ·0380 D.
71·95	·5141 ± ·0369 D.
73·95	·5362 ± ·0409 D.
75·95	·6929 ± ·0606 D.
77·95	·8214 ± ·0763 D.
80·95	1·4063 ± ·2054 D.
General Population:	·8615 ± ·0184 D.

A and *B* only

Grade of Index, 100 H/L	Mean Corneal Astigmatism
64·84	1·2917 ± ·1487 D.
67·95	1·0750 ± ·1152 D.
69·95	·6914 ± ·0789 D.
71·95	·6500 ± ·0665 D.
73·95	·5543 ± ·0658 D.
75·95	·7500 ± ·0859 D.
77·95	1·0000 ± ·0911 D.
80·95	1·4063 ± ·2230 D.
General Population:	·7649 ± ·0314 D.

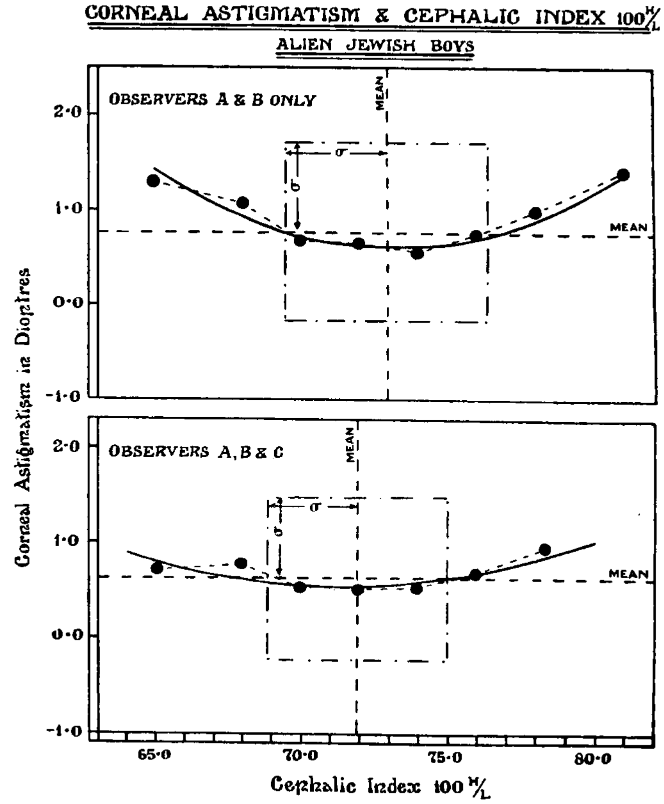

Diagram 180.

The array-means present not only a number of significant differences, but what is more important a fairly orderly sequence.

(γ) *Corneal Astigmatism and the Cephalic Index*, $I_3 = 100\ H/B$. Our data for both series are given in Tables CDII and CDIII. The constants of these tables are as follows:

		A, *B* and *C*	*A* and *B* only
Corneal Astigmatism:	Mean	·6168 D.	·7610 D.
,, ,,	Standard Deviation	·8601 D.	·9481 D.
Cephalic Index, 100 H/B:	Mean	87·1755	88·6755
,, ,,	Standard Deviation	3·9356	4·6064
Product Moment Correlation Coefficient:		$r = -\ {\cdot}0297 \pm {\cdot}0213$	$r = +\ {\cdot}0125 \pm {\cdot}0333$

This indicates that the association if significant is not linear.

Correlation Ratio of Corneal Astigmatism on Index, 100 H/B:

For *A*, *B* and *C* $\quad \eta'^2_{CA.I_3} = {\cdot}016{,}235, \quad \bar{\eta}^2_{CA.I_3} = {\cdot}006{,}986 \pm {\cdot}002{,}510.$

For *A* and *B* only $\quad \eta'^2_{CA.I_3} = {\cdot}034{,}289, \quad \bar{\eta}^2_{CA.I_3} = {\cdot}019{,}608 \pm {\cdot}006{,}548.$

Both correlation ratios are significant, if small, leading to $\eta'_{CA.I_3} = {\cdot}1274$ and ·1852 respectively. The graphs while indicating that the minimum astigmatism is reached at the modal value of the index are not so clear cut as in the case of the Index 100 H/L, and suggest vaguely a quartic

rather than a parabolic distribution. Diagram 181 shows the results for A, B and C's data, where the array-means are:

Grade of Index, 100 H/B	Mean Corneal Astigmatism
79·59	·6307 D.
81·95	·6733 D.
83·95	·6781 D.
85·95	·5413 D.
87·95	·4361 D.
89·95	·7500 D.
91·95	·7159 D.
95·89	·7179 D.
General Population:	·6168 D.

We conclude from our results that while the ratio of breadth to length of head has practically no influence on Corneal Astigmatism, that of height to either length or breadth does exercise a significant if small influence.

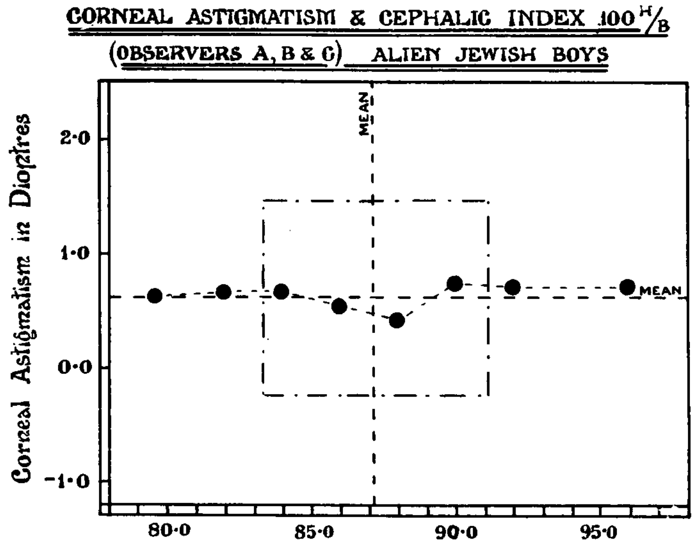

Diagram 181.

Tables CDII and CDIII. *Corneal Astigmatism and Cephalic Index*, $I_3 = 100\ H/B$.

Cephalic Index, 100 H/B (Central Values)

A, *B* and *C*

Corneal Astigmatism in Dioptres (Central Values)	75·95	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	93·95	95·95	97·95	99·95	Totals
−2·25	—	—	—	—	1	—	—	—	—	—	—	—	—	1
−1·50	—	—	—	—	3	3	—	—	—	—	—	1	—	7
−0·75	—	—	2	1	1	5	3	2·5	3	—	—	1	—	18·5
0·00	—	1	15	35	60	110	95	57	35	13	1	3	5	430
+0·75	2	2	15	33	52	97	55	59·5	33	21	5	4	5	383·5
+1·50	—	—	1	12	13	17	12	10	6	2	—	—	2	75
+2·25	—	1	5	5	9	10	5	9	5	2	—	1	—	52
+3·00	—	—	—	2	2	4	1	3	5	2	—	—	—	19
+3·75	—	—	—	—	2	1	1	2	—	—	—	—	2	8
+4·50	—	—	—	—	2	—	—	1	—	—	—	—	—	3
+5·25	—	—	—	—	1	—	—	2	1	—	—	—	—	4
+6·00	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Totals	2	4	38	88	146	248	172	146	88	40	6	10	14	1002

A and *B* only

Corneal Astigmatism in Dioptres (Central Values)	77·95	79·95	81·95	83·95	85·95	87·95	89·95	91·95	93·95	95·95	97·97	99·95	Totals
−2·25	—	—	—	—	—	—	—	—	—	—	—	—	—
−1·50	—	—	—	2	2	—	—	—	—	—	1	—	5
−0·75	—	1	1	1	4	3	2	3	—	—	1	—	16
0·00	1	6	4	5	15	21	22	19	9	1	1	5	109
+0·75	2	6	10	27	36	19	40	25	21	5	4	5	200
+1·50	—	—	4	4	5	5	9	2	2	—	—	2	33
+2·25	1	3	3	2	1	2	5	5	2	—	1	—	25
+3·00	—	—	2	1	—	—	1	3	2	—	—	—	9
+3·75	—	—	—	1	1	—	2	—	—	—	—	2	6
+4·50	—	—	—	1	—	—	1	—	—	—	—	—	2
+5·25	—	—	—	—	—	—	2	1	—	—	—	—	3
+6·00	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	4	16	24	44	64	50	84	58	36	6	8	14	408

(iii) *Corneal Astigmatism and Interpupillary Index.* The data are provided in Tables CDIV and CDV.

The constants of these tables are as follows:

	A, *B* and *C*	*A* and *B* only
Corneal Astigmatism: Mean	·6070 D.	·7593 D.
„ „ Standard Deviation	·8387 D.	·9235 D.
Interpupillary Index: Mean	39·8253	39·0520
„ „ Standard Deviation	2·1835	2·3195
Product Moment Correlation Coefficient:	$r = + \cdot 0297 \pm \cdot 0215$	$r = + \cdot 1045 \pm \cdot 0333$

Thus the correlation, if linear, is small and seems to be obscured by adding C's observations to A and B's.

Correlation Ratio of Corneal Astigmatism on Interpupillary Index:

For A, B and C $\quad \eta'^2_{CA.IpI} = \cdot 008{,}728, \quad \bar{\eta}^2_{CA.IpI} = \cdot 009{,}128 \pm \cdot 002{,}889.$

For A and B only $\quad \eta'^2_{CA.IpI} = \cdot 051{,}139, \quad \bar{\eta}^2_{CA.IpI} = \cdot 032{,}338 \pm \cdot 008{,}407.$

Tables CDIV and CDV. *Corneal Astigmatism and Interpupillary Index.*

Corneal Astigmatism in Dioptres (Central Values)

Central Values: Inter-pupillary Index	*A*, *B* and *C*													*A* and *B* only										
	−2·25	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	+6·00	Totals	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	Totals
34·45	—	—	1	3	2	—	—	—	—	—	—	—	6	—	1	1	2	—	—	—	—	—	—	4
35·45	—	—	1	4	15	—	—	—	—	—	—	—	20	—	1	2	11	—	—	—	—	—	—	14
36·45	—	—	2	23	22	5	—	—	—	—	—	—	52	—	2	12	21	5	—	—	—	—	—	40
37·45	—	2	2	44	45	3	5	1	—	—	—	—	102	2	2	26	32	2	5	1	—	—	—	70
38·45	—	1	6·5	62	84·5	15	9	4	—	—	2	—	184	1	6	24	45	6	6	4	—	—	2	94
39·45	1	1	1	75	59	16	10	4	4	1	—	—	172	—	1	19	36	8	5	1	3	1	—	74
40·45	—	1	3	87	53	15	19	1	1	—	1	1	182	—	1	12	22	9	7	—	—	—	1	52
41·45	—	—	1	52	45	9	4	—	2	1	—	—	114	—	1	2	10	1	1	—	2	1	—	18
42·45	—	—	—	37	27	6	1	2	—	—	1	—	74	—	—	2	7	1	—	—	—	—	—	10
43·45	—	—	1	26	15	3	1	4	—	—	—	—	50	—	1	4	4	1	—	2	—	—	—	12
44·45	—	—	—	7	1	—	—	2	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—
45·45	—	—	—	1	7	—	—	—	—	—	—	—	8	—	—	1	3	—	—	—	—	—	—	4
46·45	—	—	—	3	2	—	1	—	—	—	—	—	6	—	—	1	2	—	1	—	—	—	—	4
47·45	—	—	—	2	2	—	—	—	—	—	—	—	4	—	—	2	2	—	—	—	—	—	—	4
48·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49·45	—	—	—	1	1	—	—	—	—	—	—	—	2	—	—	1	1	—	—	—	—	—	—	2
Totals	1	5	18·5	427	380·5	72	50	18	7	2	4	1	986	3	16	109	198	33	25	8	5	2	3	402

The A, B and C series gives no significant association; the A and B only gives a relation of very doubtful significance, having regard to the value of $\bar{\eta}^2$ and its probable error.

On the other hand for the A and B series only the array-means show a fairly uniform rise in the Corneal Astigmatism with increasing index until we come to the last array at 45·30, where there is a rapid fall. Accordingly we should have a small evolutionary force tending to bring the pupils closer together—assuming that Corneal Astigmatism in the early development of man was a real disadvantage. The array-means are as follows:

Grade of Interpupillary Index (A, B and C)	Mean Corneal Astigmatism
35·22	·4327 D. ± ·1109
36·45	·4327 D. ± ·0784
37·45	·4779 D. ± ·0560
38·45	·6644 D. ± ·0417
39·45	·6759 D. ± ·0431
40·45	·6593 D. ± ·0419
41·45	·5921 D. ± ·0530
42·45	·5777 D. ± ·0658
43·45	·5833 D. ± ·0800
45·85	·6000 D. ± ·1033
General Population:	·6070 D. ± ·0180

Grade of Interpupillary Index (A and B only)	Mean Corneal Astigmatism
35·23	·4583 D. ± ·1468
36·45	·5438 D. ± ·0985
37·45	·5250 D. ± ·0745
38·45	·7739 D. ± ·0642
39·45	·9223 D. ± ·0724
40·45	·9663 D. ± ·0864
41·81	1·0446 D. ± ·1177
45·30	·6923 D. ± ·1222
General Population:	·7593 D. ± ·0311

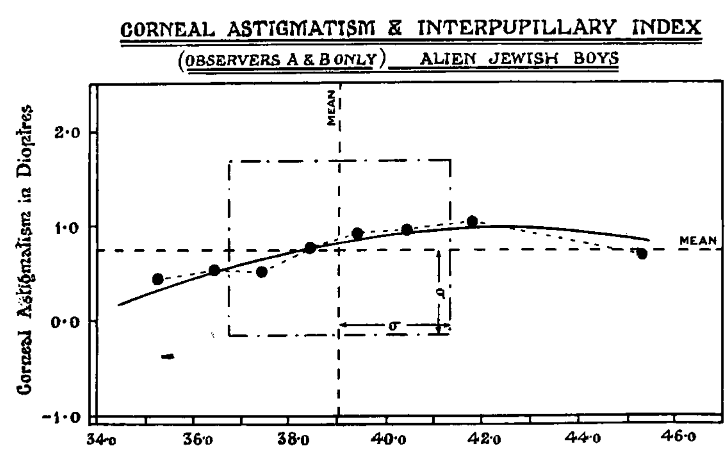

Diagram 182.

While the probable errors are too great to stress heavily the differentiation of any individual mean, the general run of the means especially in the second series does seem to indicate that

relatively great distance of the pupils apart does increase the Corneal Astigmatism. This is illustrated in Diagram 182 which gives the A and B only series fitted with a cubic.

(iv) *Corneal Astigmatism and Index of Sunken Eye.* The data for our two series are given in Tables CDVI and CDVII below. The constants of these tables are as follows:

	A, B and C	A and B only
Corneal Astigmatism: Mean	·6160 D.	·7592 D.
,, ,, Standard Deviation	·8597 D.	·9343 D.
Index of Sunken Eye: Mean	89·1227	89·4894
,, ,, Standard Deviation	2·8504	3·2139
Product Moment Correlation Coefficient:	$r = -\cdot 0142 \pm \cdot 0213$	$r = -\cdot 1139 \pm \cdot 0330$

The correlation coefficient if significant on the shorter series is not so on the longer series, and the array-means indicate non-linear regression.

Correlation Ratio of Corneal Astigmatism on Index:

For A, B and C $\quad \eta'^2_{CA.SEI} = \cdot 033{,}674, \quad \bar{\eta}^2_{CA.SEI} = \cdot 009{,}980 \pm \cdot 002{,}996.$

For A and B only $\quad \eta'^2_{CA.SEI} = \cdot 046{,}240, \quad \bar{\eta}^2_{CA.SEI} = \cdot 024{,}631 \pm \cdot 007{,}340.$

In both cases the correlation ratios are significant and we have $\eta'_{CA.SEI} = \cdot 1835$ and $\cdot 2150$ respectively. The means of the arrays indicate that the regression is of a parabolic type—individuals with values of the index near the mode having least astigmatism.

Grade of Index of Sunken Eye (A, B and C)	Mean Corneal Astigmatism	Grade of Index of Sunken Eye (A and B only)	Mean Corneal Astigmatism
82·53	1·0385 D.	83·12	1·2500 D.
85·05	·6750 D.	85·45	·9205 D.
86·45	·7159 D.	86·45	·8487 D.
87·45	·6951 D.	87·45	·9219 D.
88·45	·4984 D.	88·45	·6914 D.
89·45	·5966 D.	89·45	·8750 D.
90·45	·4234 D.	90·45	·4539 D.
91·45	·6730 D.	91·45	·5938 D.
92·45	·5676 D.	92·45	·4375 D.
93·45	·4219 D.	93·45	·6563 D.
95·14	·97 0 D.	95·58	·8906 D.
General Population:	·6160 D.	General Population:	·7592 D.

Tables CDVI and CDVII. *Corneal Astigmatism and Index of Sunken Eye.*

Corneal Astigmatism in Dioptres (Central Values)

Observers A, B and C

Index of Sunken Eye (Central Values)	−2·25	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	+6·00	Totals
78·45	—	—	—	—	—	2	—	—	—	—	—	—	2
79·45	—	—	—	—	—	—	—	—	—	—	—	—	—
80·45	—	—	—	2	2	—	—	—	—	—	—	—	4
81·45	—	—	—	—	—	—	—	—	—	—	—	—	—
82·45	—	—	—	1	1	—	—	—	—	—	—	—	2
83·45	—	—	1	3	10	—	2	—	—	—	2	—	18
84·45	—	—	—	7	14	—	1	2	—	—	—	—	24
85·45	—	1	2	15	12	2	2	—	1	1	—	—	36
86·45	—	2	2	24	25	5	4	—	3	—	1	—	66
87·45	—	—	1	30	37	8	1	4	1	—	—	—	82
88·45	—	—	3	76	63	7	8	—	—	—	1	—	158
89·45	—	—	2	65	46	7	8	1	1	1	—	1	132
90·45	—	1	2·5	64	44·5	8	2	2	—	—	—	—	124
91·45	—	2	1	63	47	16	11	6	—	—	—	—	146
92·45	—	—	1	35	27	5	5	—	1	—	—	—	74
93·45	1	1	3	26	26	4	2	1	—	—	—	—	64
94·45	—	—	—	10	20	6	5	3	1	1	—	—	46
95·45	—	—	—	6	4	2	—	—	—	—	—	—	12
96·45	—	—	—	2	4	—	—	—	—	—	—	—	6
97·45	—	—	—	1	1	—	—	—	—	—	—	—	2
98·45	—	—	—	—	—	1	1	—	—	—	—	—	2
99·45	—	—	—	—	1	1	—	—	—	—	—	—	2
Totals	1	7	18·5	430	384·5	74	52	19	8	3	4	1	1002

Observers A and B only

Index of Sunken Eye (Central Values)	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	Totals
78·45	—	—	—	—	2	—	—	—	—	—	2
79·45	—	—	—	—	—	—	—	—	—	—	—
80·45	—	—	1	1	—	—	—	—	—	—	2
81·45	—	—	—	—	—	—	—	—	—	—	—
82·45	—	—	1	1	—	—	—	—	—	—	2
83·45	—	1	1	4	—	—	—	—	—	2	8
84·45	—	—	1	6	—	1	2	—	—	—	10
85·45	—	2	6	8	2	2	—	1	1	—	22
86·45	2	2	13	11	2	4	—	3	—	1	38
87·45	—	1	11	24	6	1	4	1	—	—	48
88·45	—	2	14	40	3	5	—	—	—	—	64
89·45	—	1	10	18	2	2	1	1	1	—	36
90·45	1	2	14	17	2	2	—	—	—	—	38
91·45	2	1	15	21	6	2	1	—	—	—	48
92·45	—	1	11	10	1	1	—	—	—	—	24
93·45	—	3	7	17	2	2	1	—	—	—	32
94·45	—	—	2	12	2	2	—	—	—	—	18
95·45	—	—	1	3	—	—	—	—	—	—	4
96·45	—	—	—	4	—	—	—	—	—	—	4
97·45	—	—	1	1	—	—	—	—	—	—	2
98·45	—	—	—	—	1	1	—	—	—	—	2
99·45	—	—	—	1	1	—	—	—	—	—	2
Totals	5	16	109	199	32	25	9	6	2	3	406

Diagram 183 shows the nature of the regression lines which have been fitted with second order parabolae. It is clear that very protuberant or very receding eyes are both likely to have excess of Corneal Astigmatism. The equations to the two parabolae are:

For A, B and C:

$$CA = \cdot 55592 - \cdot 00558\,(I - 89\cdot 45) + \cdot 00745\,(I - 89\cdot 45)^2.$$

For A and B only:

$$CA = \cdot 61922 - \cdot 034747\,(I - 89\cdot 45) + \cdot 006374\,(I - 89\cdot 45)^2.$$

Generally we hold that there is association between Corneal Astigmatism and both pigmentation and cephalic characters, but that our data do not bring it out so emphatically as a better selection of measurements might do.

(*g*) *Distance of Near Point in relation to Pigmentation and Cephalic Characters.*

(i) *Distance of Near Point and Pigmentation.* (*a*) *Eye* (*Iris*) *Colour.* Our data will be found in Table CDVIII.

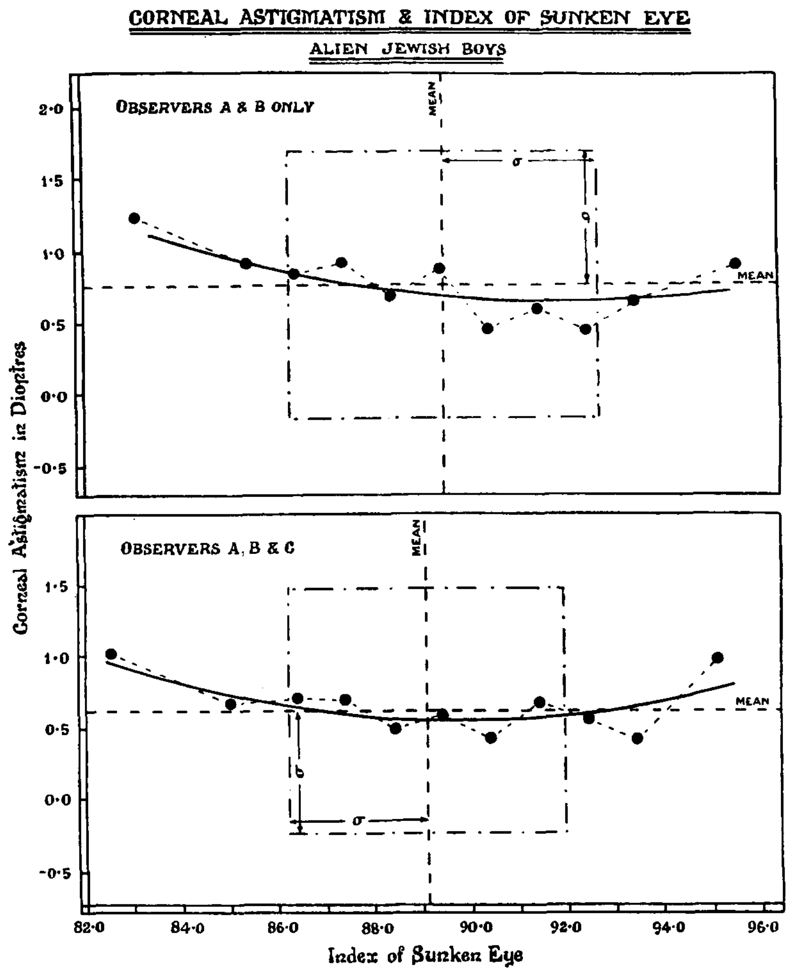

Diagram 183.

Table CDVIII. *Distance of Near Point and Eye* (*Iris*) *Colour.*

Distance of Near Point in mm. (Central Values)

Iris Colour	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	..	200	Totals
Dark Brown	—	—	—	—	—	1	3	6	2	8	5	5	11	5	3	4	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	..	—	56
Medium Brown	—	—	—	—	3	4	12·5	19·5	15	23	29	39	26	17	14	9	10	4	4	2	1	3	1	2	—	—	—	—	—	—	—	..	—	238
Light Brown	—	—	—	1	1	3	1	6	9	19	10	16	6	11	8	6	1	4	3	7	7	1	—	—	—	—	—	—	—	—	—	..	—	120
Hazel	1	—	—	1	1	1	3	5	7·5	14·5	13	16	11	13	6	5	8	4	6	7	3	3	1	1	—	—	—	—	—	—	—	..	1	132
Grey	—	—	2	—	—	3	2	2	11	17	13	14	13	15	9	5	3	3	1	1	3	—	3	—	—	1	—	1	1	1	—	..	—	124
Blue Grey	—	—	—	—	1	—	3	13	5	4	8	8	16	3	2	3	4	2	—	1	2	—	—	1	—	—	—	—	—	—	—	..	—	76
Pure Blue	—	—	—	—	1	1	—	—	2	3	4	2	3	1	1	3	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	..	—	24
Totals	1	—	2	2	7	13	24·5	51·5	51·5	88·5	82	100	86	65	43	35	28	18	14	21	16	7	5	4	—	1	—	1	1	1	—	..	1	770

The constants of this distribution are as follows:

Near Point Distance: Mean 93·1753 mm., Standard Deviation 20·2101 mm.

Correlation Ratio of Near Point Distance on Iris Colour:

$$\eta'^2_{NP.EC} = \cdot 021{,}727, \qquad \bar{\eta}^2_{NP.EC} = \cdot 007{,}792 \pm \cdot 003{,}019.$$

Accordingly we see that Distance of the Near Point is significantly associated with eye colour,

although with no great intensity, i.e. $\eta'_{NP.EC} = \cdot 1474$. Diagram 184 indicates the nature of the regression curve, it is one of the "basin" type with which we are now growing familiar, where a value about the middle of the range gives a maximum or minimum of the character. We have already suggested the importance of such curves for the study of evolutionary factors. The array-means obtained are here given:

Grade of Eye (Iris) Colour	Mean Distance of Near Point
Dark Brown ...	89·554 ±1·823 mm.
Medium Brown ...	90·515 ±0·884 mm.
Light Brown ...	94·917 ±1·244 mm.
Hazel	97·860 ±1·187 mm.
Grey	95·202 ±1·224 mm.
Blue Grey ...	90·329 ±1·564 mm.
Pure Blue ...	92·083 ±2·783 mm.
General Population	93·1753±·4913 mm.

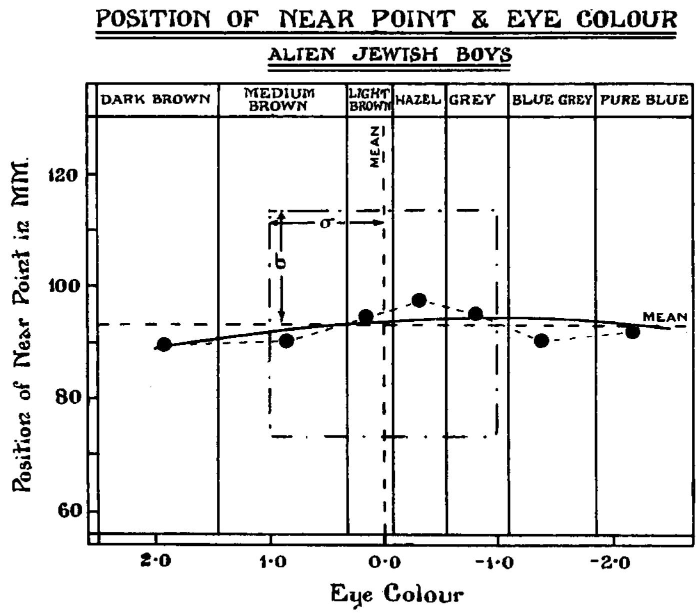

Diagram 184.

The rise of the Near Point Distance with the Hazel irides appears significant, but the variability in Near Point Distance is so large that we cannot deduce accurately on our numbers the regression curve. We have fitted it with a parabola only.

While dealing with Near Point Distance it occurred to us that it might be worth while testing whether Accommodation gave a similar result. A table was accordingly formed for Accommodation and Eye Colour. Its constants were found to be as follows:

Accommodation: Mean 11·1391 D., Standard Deviation 2·3441 D.

Correlation Ratio of Accommodation on Eye Colour:

$$\eta'^2_{Acc.EC} = \cdot 040{,}451, \qquad \bar{\eta}^2_{Acc.EC} = \cdot 008{,}596 \pm \cdot 003{,}342.$$

The association is accordingly significant ($\eta'_{Acc.EC} = \cdot 2016$).

When the array-means were determined, however, a singular state of affairs came to light. The accommodation fell steadily and uniformly from the very dark brown eyes to the greys, in other words the Accommodation lessened as the pigment lessened, but there then occurred an abrupt rise with the absence of anterior pigment in the blue eyes. It is not easy to ascertain whether this is a result purely of pigment variation, or whether the blue eyes mark the admixture of a race with a greater accommodation. The determination of similar curves for light-eyed races would be of much interest.

Table CDIX. *Accommodation and Eye Colour.*

Accommodation in Dioptres (Sub-ranges)

Eye (Iris) Colour	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	Totals
Dark Brown	—	—	—	—	—	1	1	4	15	8	6	4	6	3	2	—	—	—	—	50
Medium Brown	—	—	1	1	6	6	16	23	38	49	23	22	18	6	2	1	—	—	—	212
Light Brown	—	—	—	3	3	8	8	20	12	17	16	14	3	2	1	1	1	—	1	110
Hazel	—	—	—	—	2	10	15	16	21	27	19	8	2	2	2	—	—	—	—	124
Grey	1	1	—	4	6	1	8	11	28	19	13	14	1	—	1	—	—	—	—	108
Blue Grey	—	—	—	—	1	3	5	2	13	15	6	11	8	6	—	1	1	—	—	72
Pure Blue	—	—	—	—	—	—	3	6	3	1	4	2	1	—	1	—	1	—	—	22
Totals	1	1	1	8	18	29	56	82	130	136	87	75	39	19	9	3	3	—	1	698

Diagram 185 gives the graph of Accommodation on Eye Colour. We have not attempted to fit with a curve, as the regression is purely linear up to cessation of anterior pigment. We have little doubt that other interesting facts might be discovered by correlating Accommodation with other anthropometric characters, but this section of our present memoir has already much exceeded its projected length, and the topic cannot be discussed further now.

The array-means are:

Grade of Eye (Iris) Colour	Mean Accommodation
Dark Brown ...	11·9300 ± ·2236 D.
Medium Brown ...	11·2708 ± ·1086 D.
Light Brown ...	10·9682 ± ·1507 D.
Hazel	10·7323 ± ·1420 D.
Grey	10·5241 ± ·1521 D.
Blue Grey ...	12·0056 ± ·1863 D.
Pure Blue ...	11·4045 ± ·3371 D.
General Population	11·1391 ± ·0598 D.

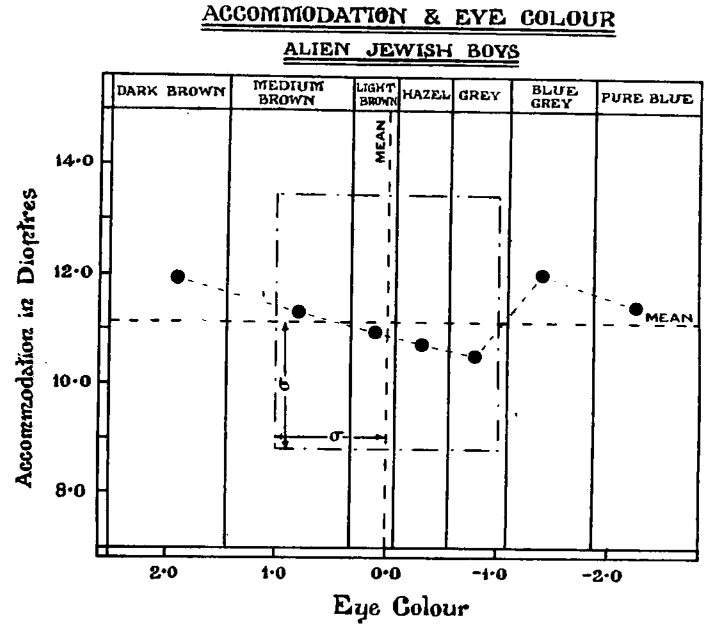

Diagram 185.

(i *b*) *Distance of Near Point and Hair Colour.* Our data are given in Table CDX. The constants are as follows:

Near Point Distance: Mean 93·1706 mm., Standard Deviation 20·2348 mm.

Correlation Ratio of Near Point Distance on Hair Colour:

$$\eta'^2_{NP.HC} = \cdot 019{,}527, \qquad \bar{\eta}^2_{NP.HC} = \cdot 007{,}812 \pm \cdot 003{,}028.$$

$\eta'_{NP.HC} = \cdot 1397$ is accordingly, if small, significant.

Table CDX. *Near Point Distance and Hair Colour.*

Near Point Distance in mm. (Central Values)

Hair Colour	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	..	200	Totals
Black	—	—	—	—	—	—	2	1	1	5	2	—	—	5	1	3	2	1	1	1	2	—	1	—	—	—	—	—	—	—	..	—	28
V. Dark Brown	—	—	—	—	2	3	6	18	6	18	11	19	19	11	4	7	1	6	1	4	3	2	1	—	—	—	—	—	—	—	..	—	142
Dark Brown	—	—	—	1	1	5	4·5	13·5	9	20	24	32	29	20	16	5	6	4	3	2	2	2	—	1	—	—	—	—	—	—	..	—	200
Medium Brown	1	—	—	1	2	3	7	11	16·5	26·5	28	28	25	22	15	16	15	4	4	8	6	2	3	3	—	—	—	—	—	—	..	1	248
Light Brown	—	—	2	—	2	1	5	8	15	16	15	16	9	4	6	4	4	2	3	6	3	1	—	—	—	—	—	1	1	—	..	—	124
Slatey	—	—	—	—	—	—	—	—	3	2	—	1	4	1	1	—	—	1	1	—	—	—	—	—	—	1	—	—	—	1	..	—	16
Red	—	—	—	—	—	1	—	—	1	1	2	3	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	..	—	10
	1	—	2	2	7	13	24·5	51·5	51·5	88·5	82	99	86	64	43	35	28	18	14	21	16	7	5	4	—	1	—	1	1	1	..	1	768

We meet with the same difficulty as we have previously noted about the proper positions for Slatey and Red Hairs. The influence of Slatey Hair on the Near Point would certainly place it near the darkest rather than the lightest hairs, but our numbers for both these hair shades are sadly too few. We have more or less to content ourselves with the array-means, without putting the hair shades into an order which would be necessary for a normal scale.

Grade of Hair Colour	Mean Near Point Distance
Slatey	102·8125 ± 3·2169
Black	100·0000 ± 2·5793
Very Dark Brown	90·7042 ± 1·1453
Dark Brown ...	91·6375 ± ·9650
Medium Brown ...	95·5141 ± ·8667
Red	88·0000 ± 4·3159
Light Brown ...	91·4113 ± 1·2256
General Population	93·1706 ± ·4925

These array-means have probable errors which suggest that Slatey, Black and Medium Brown have Near Point Distances differentiated from the General Population value, but it is not easy to trace any definite sequence in the somewhat slender association of Near Point Distance and Hair Colour with these large probable errors; that association is probably only a secondary relation arising from the correlation of Hair and Iris pigmentations and so linked with racial differences.

(ii) *Distance of Near Point and Cephalic Indices.*

(*a*) *Distance of Near Point and Cephalic Index*, $I_1 = 100\ B/L$. Our data are given in Table CDXI. The constants of this table are as follows:

Distance of Near Point: Mean 93·2702 mm., Standard Deviation 20·2171 mm.

Cephalic Index, 100 B/L: „ 82·6080 mm., „ „ 3·5792 mm.

Product Moment Correlation Coefficient:

$$r = + \cdot 0161 \pm \cdot 0244.$$

Correlation Ratio of Near Point Distance on Index:

$\eta'^2_{NP.I_1} = \cdot 021{,}849$, $\bar{\eta}^2_{NP.I_1} = \cdot 014{,}360 \pm \cdot 004.096$.

Neither correlation coefficient nor correlation ratio can be treated as significant. The array-means are very irregular.

Grade of Cephalic Index, 100 B/L	Mean Near Point Distance
72·75	91·500 ±4·312 mm.
75·95	92·794 ±2·338 mm.
77·95	96·155 ±1·544 mm.
79·95	93·462 ±1·196 mm.
81·95	91·180 ±1·136 mm.
83·95	97·647 ±1·046 mm.
85·95	93·042 ±1·245 mm.
87·95	90·200 ±1·929 mm.
90·35	90·833 ±2·400 mm.
General Population:	93·270 ± ·4930 mm.

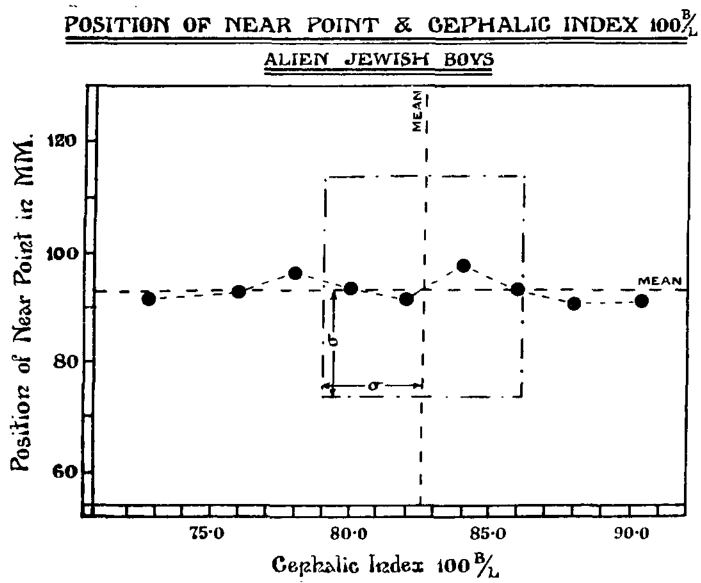

Diagram 186.

Table CDXI. *Near Point Distance and Cephalic Index*, $I_1 = 100\ B/L$.

Near Point Distance in mm. (Central Values)

Central Values: Index, 100 B/L	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	..	200	Totals
69·95	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
71·95	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
73·95	—	—	—	—	—	—	—	—	—	2	—	1	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	6
75·95	—	—	—	—	—	—	1	1	2	3	6	5	5	4	1	4	—	1	—	1	—	—	—	—	—	—	—	—	—	—	..	—	34
77·95	1	—	—	1	2	—	3	6	4	9	5	12	6	7	6	10	2	—	—	2	2	—	—	—	—	—	—	—	—	—	..	—	78
79·95	—	—	—	—	—	—	4·5	7·5	14·5	16·5	19	11	17	6	8	4	4	4	2	5	3	1	2	1	—	—	—	—	—	—	..	—	130
81·95	—	—	—	1	2	4	6	9	11	20	23	14	13	12	5	5	3	3	5	—	3	1	1	—	—	1	—	—	—	1	..	1	144
83·95	—	—	2	—	1	2	4	6	10	15	15	22	22	15	10	6	12	6	5	4	4	2	2	3	—	—	—	1	1	—	..	—	170
85·95	—	—	—	—	1	2	6	12	5	11	5	25	13	10	7	5	3	2	1	6	4	2	—	—	—	—	—	—	—	—	..	—	120
87·95	—	—	—	—	—	3	—	7	3	5	7	6	6	2	2	1	3	1	1	2	—	1	—	—	—	—	—	—	—	—	..	—	50
89·95	—	—	—	—	1	2	—	1	2	2	1	4	4	5	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	24
91·95	—	—	—	—	—	—	—	—	—	1	1	—	—	—	2	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	..	—	6
Totals	1	—	2	2	7	13	24·5	49·5	51·5	86·5	82	100	86	65	43	35	28	18	14	21	16	7	5	4	—	1	—	1	1	1	..	1	766

Only a single array-mean can be considered as significantly differentiated from the population mean, i.e. the high value for the array at index 83·95. But this mean does not fit into any orderly sequence of means (see Diagram 186) and in this as in several other cases we cannot assert that the ocular character is associated with the first cephalic index.

(β) *Distance of Near Point and Cephalic Index, $I_2 = 100\ H/L$.* The matter is different when we turn to the cephalic indices involving auricular height and this is in accordance with what we have previously found with regard to them. Table CDXII gives our data for the Cephalic Index, $100\,H/L$. In this case Diagram 187 indicates that we again get a more or less parabolic form of the regression curve. For constants we find:

Near Point Distance: Mean 93·2702 mm., Standard Deviation 20·2171 mm.

Cephalic Index, $100\,H/L$: „ 71·6628 mm., „ „ 2·9816 mm.

Product Moment Correlation Coefficient: $r = -\cdot 0806 \pm \cdot 0202$.

Correlation Ratio of Near Point Distance on Cephalic Index:

$$\eta'^2_{NP.I_2} = \cdot 028{,}777, \qquad \bar{\eta}^2_{NP.I_2} = \cdot 013{,}055 \pm \cdot 003{,}877.$$

Thus the association is significant and the value of $\eta'_{NP.I_2}$ ($= \cdot 1696$) shows that it is skew. The array-means are as follows:

Grade of Cephalic Index, 100 H/L	Mean Distance of Near Point
63·09	90·536 ± 3·644 mm.
65·95	94·808 ± 2·674 mm.
67·95	91·616 ± 1·506 mm.
69·95	97·926 ± ·994 mm.
71·95	92·712 ± ·936 mm.
73·95	93·219 ± 1·129 mm.
75·95	86·172 ± 1·705 mm.
78·30	88·971 ± 2·339 mm.
General Population:	93·270 ± ·489 mm.

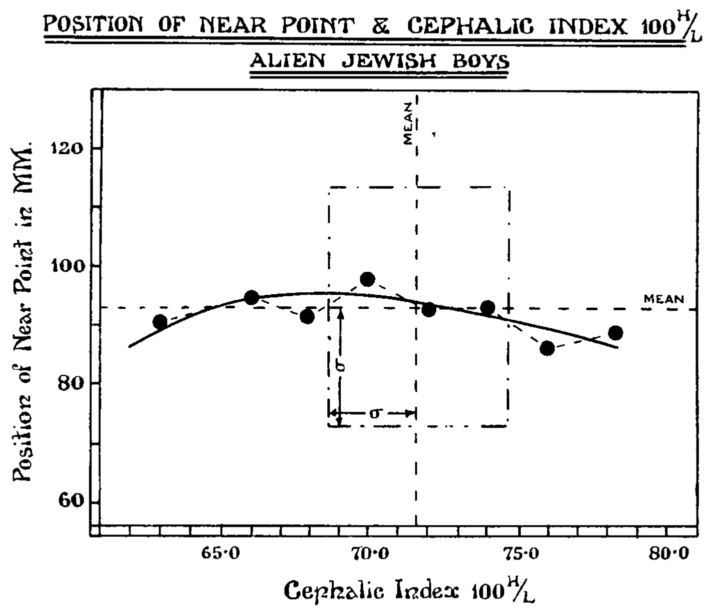

Diagram 187.

Two or three of the arrays have significantly differentiated means, but clearly large numbers are requisite, owing to the great variability of the near point, to obtain adequate determinations. We think, however, that there is enough evidence to show that the maximum mean Near Point Distance occurs near the modal value of the Index, and that the Near Point Distance becomes smaller for both increase and decrease of the Index from this value.

Table CDXII. *Near Point Distance and Cephalic Index, $I_2 = 100\ H/L$.*

Near Point Distance in mm. (Central Values)

Central Values: Index, 100 H/L	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	..	200	Totals
59·95	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
61·95	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
63·95	—	—	—	—	—	—	1	—	0·5	1·5	1	2	2	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	10
65·95	—	—	—	1	—	—	1	—	—	3	2	2	5	4	2	4	1	1	—	—	—	—	—	—	—	—	—	—	—	—	..	—	26
67·95	1	—	—	—	—	3	4·5	3·5	8	12	9	4	10	7	4	5	2	2	—	1	1	2	2	1	—	—	—	—	—	—	..	—	82
69·95	—	—	—	1	1	1	3	6	11	17	19	38	14	16	10	11	8	7	2	8	7	2	3	—	—	1	—	1	—	1	..	—	188
71·95	—	—	—	—	3	2	7	21	16	17	26	22	30	14	16	8	8	2	6	5	3	3	—	2	—	—	—	—	—	—	..	1	212
73·95	—	—	—	—	2	2	3	13	8	19	16	16	15	17	6	3	6	5	3	6	5	—	—	1	—	—	—	—	—	—	..	—	146
75·95	—	—	2	—	1	3	3	3	5	12	7	7	6	4	4	1	2	1	3	—	—	—	—	—	—	—	—	—	—	—	..	—	64
77·95	—	—	—	—	—	1	2	2	3	3	1	8	4	1	—	1	—	—	—	1	—	—	—	—	—	—	—	—	1	—	..	—	28
79·95	—	—	—	—	—	1	—	1	—	—	1	1	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	6
Totals	1	—	2	2	7	13	24·5	49·5	51·5	86·5	82	100	86	65	43	35	28	18	14	21	16	7	5	4	—	1	—	1	1	1	..	1	766

(γ) *Near Point Distance and Cephalic Index,* $I_3 = 100\,H/B$. Our data will be found in Table CDXIII, and the following constants have been found for the table:

Near Point Distance: Mean 93·1753 mm., Standard Deviation 20·2101 mm.

Cephalic Index, 100 H/B: ,, 86·8694 mm., ,, ,, 3·7194 mm.

Product Moment Correlation Coefficient: $r = -\cdot 1161 \pm \cdot 0240$.

Correlation Ratio of Near Point Distance on Index:

$$\eta'^2_{NP.I_3} = \cdot 030{,}504, \qquad \bar{\eta}^2_{NP.I_3} = \cdot 015{,}584 \pm \cdot 004{,}253.$$

Here r is small but significant, and η'^2 is significant having regard to $\bar{\eta}^2$; the value of $\eta'_{NP.I_3}$ is ·1717. The regression curve cannot with satisfaction be looked upon as linear, although there is a distinct tendency for auricular heights large as compared with the breadth to have low values of the Near Point Distance, and for auricular heights small compared with the breadth to have high values of the Near Point Distance. We have graduated the array-means by aid of a cubic: see Diagram 188.

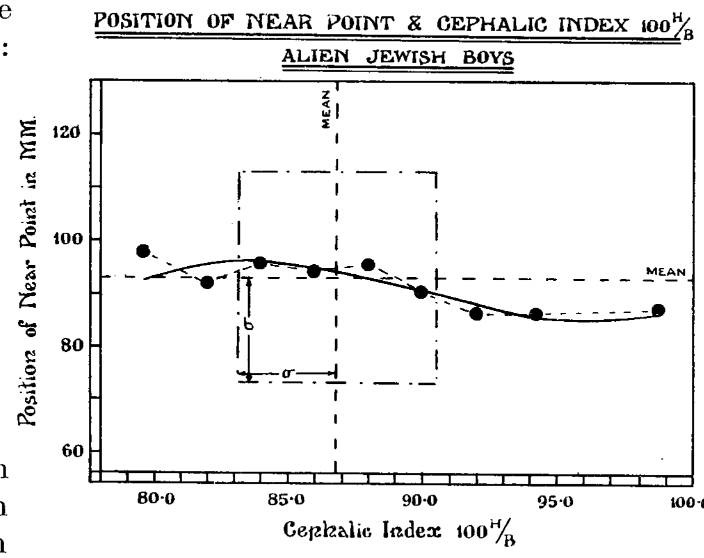

Diagram 188.

The array-means are as follows:

Grade of Cephalic Index, 100 H/B	Mean Distance of Near Point
79·60	97·868 ± 2·338 mm.
81·95	92·059 ± 1·653 mm.
83·95	95·479 ± 1·244 mm.
85·95	94·238 ± ·941 mm.
87·95	95·571 ± 1·152 mm.
89·95	90·510 ± 1·377 mm.
91·95	86·333 ± 1·760 mm.
94·28	86·667 ± 2·783 mm.
98·70	87·500 ± 3·408 mm.
General Population:	93·175 ± ·491 mm.

Little can be asserted as to the differentiation of individual means, but the sequence as shown in the graph is fairly regular, and taken in conjunction with the significance of the correlational measures, we think it probable that vision is influenced by the ratio of height to breadth of the head.

Table CDXIII. *Near Point Distance and Cephalic Index,* $I_3 = 100\,H/B$.

Near Point Distance in mm. (Central Values)

Central Values: Index, 100 H/B	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	..	200	Totals
75·95	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
77·95	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
79·95	—	—	—	—	—	—	1	—	0·5	4·5	1	4	4	5	1	4	2	—	—	2	—	1	—	—	—	—	—	—	—	—	..	—	30
81·95	—	—	—	—	1	2	3	2	7	6	4	11	11	5	7	—	1	3	—	4	—	1	—	—	—	—	—	—	—	—	..	—	68
83·95	—	—	—	1	—	6	4·5	12·5	4	11	10	21	6	8	5	3	7	4	—	1	6	3	4	—	—	1	—	1	—	1	..	—	120
85·95	1	—	—	1	2	1	7	12	14	16	28	24	24	20	18	8	11	2	5	7	3	2	1	3	—	—	—	—	—	—	..	—	210
87·95	—	—	—	—	1	2	1	8	9	20	17	11	20	13	2	9	2	9	6	4	4	—	—	1	—	—	—	—	—	—	..	1	140
89·95	—	—	—	—	1	1	4	5	11	12	9	12	14	9	8	4	3	—	1	1	3	—	—	—	—	—	—	—	—	—	..	—	98
91·95	—	—	2	—	2	1	2	8	3	6	6	12	5	2	2	4	2	—	2	1	—	—	—	—	—	—	—	—	—	—	..	—	60
93·95	—	—	—	—	—	—	1	1	1	3	7	4	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	..	—	20
95·95	—	—	—	—	—	—	1	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	4
97·95	—	—	—	—	—	—	—	—	—	6	—	—	—	2	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	..	—	10
99·95	—	—	—	—	—	—	—	2	2	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	6
Totals	1	—	2	2	7	13	24·5	51·5	51·5	88·5	82	100	86	65	43	35	28	18	14	21	16	7	5	4	—	1	—	1	1	1	..	1	770

(iii) *Distance of Near Point and Interpupillary Index.* Our data are recorded in Table CDXIV, and the graph (Diagram 189) indicates that with the exception of the two terminal arrays there is a steady if small increase of the Near Point Distance from Interpupillary index 36·45 to 43·45. The constants of the table are as follows:

Near Point Distance: Mean 93·1348 mm., Standard Deviation 20·2075 mm.

Interpupillary Index: „ 40·0388 mm., „ „ 2·2012 mm.

Product Moment Correlation Coefficient: $r = + \cdot 0506 \pm \cdot 0243$.

Correlation Ratio of Near Point Distance on Interpupillary Index:

$$\eta'^2_{NP.IpI} = \cdot 034{,}332, \quad \bar{\eta}^2_{NP.IpI} = \cdot 018{,}325 \pm \cdot 004{,}619.$$

We see from these results that while r is non-significant $\eta'^2_{NP.IpI}$ is quite possibly significant. The array-means are as follows:

Grade of Interpupillary Index	Mean Near Point Distance
35·20	98·750 ±3·407 mm.
36·45	85·263 ±2·211 mm.
37·45	89·194 ±1·731 mm.
38·45	90·707 ±1·160 mm.
39·45	93·962 ±1·195 mm.
40·45	94·859 ±1·144 mm.
41·45	96·887 ±1·349 mm.
42·45	94·375 ±1·704 mm.
43·45	97·500 ±2·010 mm.
45·91	84·423 ±2·673 mm.
General Population:	93·135 ± ·493 mm.

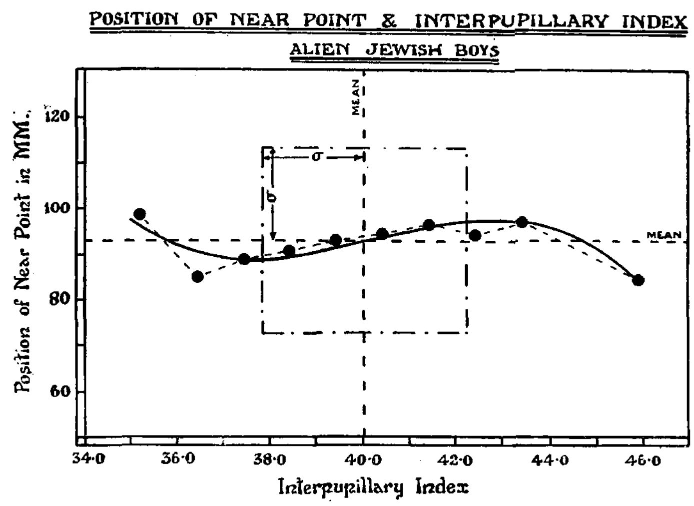

Diagram 189.

Again, little is to be learnt by testing individual means by aid of their probable errors. We can trust only to the impression formed by the total system and the probably significant value of $\eta'_{NP.IpI}$. We may sum up the situation by stating that it is possible that there is a small increase of Near Point Distance as the pupils relative to the breadth of the head are farther apart. But the relation cannot be definitely asserted on the basis of our data.

Table CDXIV. *Near Point Distance and Interpupillary Index.*

Near Point Distance in mm. (Central Values)

Central Values

Interpupillary Index	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	..	200	Totals
34·45	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	..	—	4
35·45	—	—	—	—	—	1	—	2	—	1	—	2	1	—	1	—	—	1	2	—	—	1	—	—	—	—	—	—	—	—	..	—	12
36·45	—	—	—	—	1	1	1	4	6	5	3	7	3	5	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	38
37·45	—	—	—	—	—	1	3	8	6	14	3	7	2	4	1	3	4	1	1	3	—	1	—	—	—	—	—	—	—	—	..	—	62
38·45	—	—	—	—	—	4	6	12	8·5	18·5	17	18	14	10	9	6	4	1	—	4	3	2	1	—	—	—	—	—	—	—	..	—	138
39·45	—	—	2	—	4	2	8	11	8	9	11	17	17	4	6	2	4	7	4	5	2	1	2	1	—	—	—	1	1	—	..	1	130
40·45	—	—	—	1	2	1	1	5	10	14	16	21	15	23	10	6	4	—	2	3	3	1	1	1	—	1	—	—	—	1	..	—	142
41·45	1	—	—	—	—	2	3·5	2·5	4	3	15	11	15	10	8	8	7	4	2	—	3	1	1	1	—	—	—	—	—	—	..	—	102
42·45	—	—	—	1	—	—	2	2	5	9	10	8	2	5	3	5	3	4	1	1	2	—	—	1	—	—	—	—	—	—	..	—	64
43·45	—	—	—	—	—	—	—	—	1	5	7	5	11	3	4	4	1	—	2	2	1	—	—	—	—	—	—	—	—	—	..	—	46
44·45	—	—	—	—	—	1	—	—	—	1	—	1	5	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	10
45·45	—	—	—	—	—	—	—	1	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	4
46·45	—	—	—	—	—	—	—	—	—	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	6
47·45	—	—	—	—	—	—	—	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	4
48·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	—
49·45	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
Totals	1	—	2	2	7	13	24·5	51·5	49·5	88·5	82	100	85	64	43	35	27	18	14	20	16	7	5	4	—	1	—	1	1	1	..	1	764

(iv) *Near Point Distance and Index of Sunken Eye.* The data are collected in Table CDXV. The constants deduced from this table are as follows:

Near Point Distance: Mean 93·1753 mm., Standard Deviation 20·2101 mm.

Index of Sunken Eye: ,, 89·8526 mm., ,, ,, 2·7400 mm.

Product Moment Correlation Coefficient: $r = \cdot 0035 \pm \cdot 0243$.

Correlation Ratio of Near Point Distance on Index:

$$\eta'^2_{NP.SEI} = \cdot 041{,}082,$$

$$\bar{\eta}^2_{NP.SEI} = \cdot 020{,}779 \pm \cdot 004{,}899.$$

Clearly r is non-significant, but having regard to $\bar{\eta}^2_{NP.SEI}$ and its probable error $\eta'^2_{NP.SEI}$ must be considered significant. The first two array-means are, however, extremely erratic (see Diagram 190) and it is necessary to consider whether this can be due to the smallness of their frequencies.

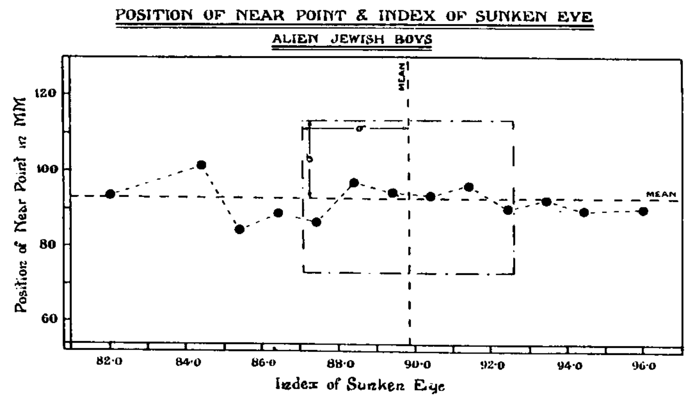

Diagram 190.

Grade of Index of Sunken Eye	Mean Near Point Distance
82·02	93·571 ±3·643 mm.
84·45	101·667 ±3·213 mm.
85·45	84·643 ±2·576 mm.
86·45	88·843 ±1·855 mm.
87·45	86·354 ±1·967 mm.
88·45	97·364 ±1·300 mm.
89·45	94·555 ±1·255 mm.

Grade of Index of Sunken Eye	Mean Near Point Distance
90·45	93·889 ±1·312 mm.
91·45	96·136 ±1·300 mm.
92·45	90·227 ±1·678 mm.
93·45	92·400 ±1·928 mm.
94·45	89·821 ±2·576 mm.
96·01	90·000 ±3·213 mm.
General Population:	93·175 ± ·491 mm.

There is thus no doubt as to the significance of the dip from 85·45 to 87·45, although the actual values at 82·02 and 84·45 are somewhat uncertain, but the latter could hardly have an

Table CDXV. *Near Point Distance and Index of Sunken Eye.*

Near Point Distance in mm. (Central Values)

Central Values

Index of Sunken Eye	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	..	200	Totals
76·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
80·45	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
81·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	—
82·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	—
83·45	—	—	—	—	—	—	—	2	—	—	2	2	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	10
84·45	—	—	—	—	—	—	—	—	—	2	1	5	2	—	1	3	1	—	1	1	—	1	—	—	—	—	—	—	—	—	..	—	18
85·45	—	—	—	1	—	—	1	—	8	6	3	1	4	2	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	..	—	28
86·45	1	—	—	—	—	2	0·5	3·5	4	10	4	11	4	5	3	2	—	—	—	4	—	—	—	—	—	—	—	—	—	—	..	—	54
87·45	—	—	—	—	1	1	3	5	3	8	4	6	8	1	5	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	..	—	48
88·45	—	—	—	—	—	1	4	8	6	7	15	9	8	15	5	5	4	7	6	4	4	1	—	1	—	—	—	—	—	—	..	—	110
89·45	—	—	—	1	2	4	3	11	6·5	5·5	9	10	18	12	9	3	8	5	2	3	4	1	—	—	—	—	—	—	1	—	..	—	118
90·45	—	—	—	—	—	—	2	6	8	16	11	18	9	6	9	8	6	1	1	3	2	2	—	—	—	—	—	—	—	—	..	—	108
91·45	—	—	—	—	1	1	4	5	7	11	16	14	14	7	4	5	4	2	4	2	2	1	3	1	—	—	—	1	—	—	..	1	110
92·45	—	—	—	—	2	—	3	5	6	8	9	7	8	7	4	2	2	—	—	—	—	—	1	—	—	1	—	—	—	1	..	—	66
93·45	—	—	—	—	—	—	2	3	3	11	3	11	5	4	1	—	—	1	—	2	1	1	1	1	—	—	—	—	—	—	..	—	50
94·45	—	—	—	—	1	3	—	2	—	2	2	5	4	5	1	1	—	—	—	1	1	—	—	—	—	—	—	—	—	—	..	—	28
95·45	—	—	2	—	—	1	1	—	—	2	—	—	—	—	—	—	—	2	—	—	1	—	—	1	—	—	—	—	—	—	..	—	10
96·45	—	—	—	—	—	—	—	—	—	—	1	1	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	6
97·45	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	2
Totals	1	—	2	2	7	13	24·5	51·5	51·5	88·5	82	100	86	65	43	35	28	18	14	21	16	7	5	4	—	1	—	1	1	1	..	1	770

array-mean as low as the dip, even if the true value of the mean were less by 4 to 5 times the probable error. Beyond the dip there is scarcely any significant divergence from the mean of the General Population. It seems hard to discover any circumstances which would account for the singular nature of the regression curve in this character, but the receding or protuberant character of the eye does appear to affect the Near Point, although the *modus operandi* is far from clear.

(*h*) *Correlation of Pigmentation with Index of Sunken Eye and Interpupillary Index.* The fact that ocular characters seem to be correlated with pigmentation and cephalic lengths, if only in a slight but yet significant degree, leads us back to the question of whether such characters actually influence the vision or are indications of racial differences and racial admixtures. If the variations of vision with iris pigmentation and with cephalic indices of diverse kinds are due to race we might expect that Eye Colour would exhibit correlation with such characters as the Interpupillary Index and the Index of the Sunken Eye, and we accordingly formed tables of these variates with Eye Colour.

(i) *Index of Sunken Eye and Eye* (*Iris*) *Colour.* Our data will be found in Table CDXVI.

Table CDXVI. *Index of Sunken Eye and Eye* (*Iris*) *Colour.*

Index of Sunken Eye (Central Values)

Eye Colour	76·45	77·45	78·45	79·45	80·45	81·45	82·45	83·45	84·45	85·45	86·45	87·45	88·45	89·45	90·45	91·45	92·45	93·45	94·45	95·45	96·45	97·45	98·45	99·45	Totals
Dark Brown	—	—	—	—	—	—	—	—	1	1	4	3	5	5	5	6	—	3	2	—	1	—	—	—	36
Medium Brown	1	—	—	—	1	—	—	2	4	3	6	10	26	15	23	22	15	9	6	2	2	—	—	—	147
Light Brown	—	—	—	—	—	—	—	1	2	4	7	12	15	11	14	14	3	4	7	1	—	—	—	—	95
Hazel	—	—	1	—	—	—	2	2	2	3	5	8	15	10	9	17	5	7	3	—	—	1	1	1	92
Grey	—	—	—	—	—	—	—	2	2	1	10	2	11	18	8	8	7	5	1	2	—	—	—	—	77
Blue Grey	—	—	—	—	1	—	—	2	1	5	2	5	6	6	4	6	4	4	4	1	—	—	—	—	51
Pure Blue	—	—	—	—	—	—	—	1	1	2	1	2	2	4	—	1	3	1	—	—	1	—	—	—	19
Totals	1	—	1	—	2	—	2	10	13	19	35	42	80	69	63	74	37	33	23	6	4	1	1	1	517

The constants of this table are as follows:

Index of Sunken Eye: Mean 89·7092, Standard Deviation 2·9424.

Correlation Ratio of Index on Eye Colour:

$$\eta'^2_{SEI.EC} = \cdot 004{,}458, \qquad \bar{\eta}^2_{SEI.EC} = \cdot 011{,}605 \pm \cdot 004{,}490.$$

Clearly the correlation ratio is non-significant. The array-means tell the same tale:

Grade of Iris Pigmentation	Mean Index of Sunken Eye
Dark Brown ...	89·839 ± ·331
Medium Brown ...	89·953 ± ·164
Light Brown ...	89·618 ± ·204
Hazel	89·700 ± ·207
Grey	89·593 ± ·226
Blue Grey ...	89·489 ± ·278
Pure Blue - ...	89·134 ± ·455
General Population	89·709 ± ·087

Not a single array-mean is definitely differentiated from the mean of the General Population, and we conclude that the condition of relatively protuberant or relatively recedent eyes has no relation to Iris Pigmentation.

(ii) *Interpupillary Index and Eye (Iris) Colour.* Table CDXVII gives our data.

Table CDXVII. *Interpupillary Index and Eye (Iris) Colour.*

Interpupillary Index (Central Values)

Eye Colour	34·45	35·45	36·45	37·45	38·45	39·45	40·45	41·45	42·45	43·45	44·45	45·45	46·45	47·45	48·45	49·45	Totals
Dark Brown	—	2	2	3	5	6	5	5	2	2	1	2	—	—	—	—	35
Medium Brown	—	6	7	12	27	22	28	20	13	8	1	—	—	—	—	1	145
Light Brown	1	—	5	12	17	18	19	4	9	7	2	—	1	—	—	—	95
Hazel	1	1	8	11	11	12	22	16	4	2	—	—	1	1	—	—	90
Grey	—	—	3	9	18	14	11	9	6	3	1	—	1	—	—	—	75
Blue Grey	1	1	2	2	12	12	7	4	3	3	—	3	—	1	—	—	51
Pure Blue	—	—	2	3	5	3	—	3	—	1	—	—	—	—	—	—	17
Totals	3	10	29	52	95	87	92	61	37	26	5	5	3	2	—	1	508

The constants of this table are as follows:

Mean Index = 39·8240, Standard Deviation of Index = 2·1964.

Correlation Ratio of Interpupillary Index on Eye Colour:

$$\eta'^2_{IpI.EC} = \cdot 006{,}755, \qquad \bar{\eta}^2_{IpI.EC} = \cdot 011{,}811 \pm \cdot 004{,}569.$$

Accordingly the correlation ratio appears non-significant as far as our material reaches. The same result appears from examination of the array-means:

Grade of Iris Pigmentation	Mean Interpupillary Index
Dark Brown ...	40·050 ± ·250
Medium Brown ...	39·850 ± ·123
Light Brown ...	39·850 ± ·152
Hazel	39·736 ± ·156
Grey	39·797 ± ·171
Blue Grey ...	40·058 ± ·207
Pure Blue ...	39·038 ± ·359
General Population	39·824 ± ·066

Thus while Interpupillary Index and Iris Pigmentation both show indications of association with ocular characters, not a single one of the above array-means is significantly different from that of the General Population, or we must hold the Interpupillary Index to be independent of Iris Pigmentation. The phenomena of near or far set eyes and of protuberant or receding eyes are uncorrelated with Eye Colour. These results are noteworthy as they tend to emphasise the importance of the occasions when we do detect by aid of the correlation ratio and probable errors of array-means slight but significant associations. Here nothing is to be found by these processes*.

Conclusions. To sum up this section of our work, we must admit that with our present ophthalmic data and the head measurements *a priori* selected we have not reached *close* correlations between the ocular characters and either pigmentation or cephalic measurements. But in breaking what we believe to be new ground we have come across indications that such correlations probably exist, and that their discovery depends upon more ample material, more delicate ophthalmic observations and an extended system of cephalic measurements. The latter must be more or less

* At the same time the reader who will carefully compare the array-means with the population mean in the last table, disregarding the non-significance of η' and the individual probable errors, will be likely to conclude with us that there is possibly a very slight tendency for the eyes with dark irides to be more close set, and even here to see a suggestion of racial relationship.

tentative until we have discovered the more closely associated factors. But the reader who has carefully followed our sections on the relation of vision to intelligence, school work and environmental factors will certainly conclude with us that there is far more hope of showing vision as a function of anthropometric characters than a product say of environment. In other words it is a question of race, rather than of immediate surroundings. We say "immediate" surroundings for race itself is in our view the integration of the effects of an indefinitely long historical environment. How far the poor sight of the Jews reaches back to their oriental racial origin or is a product of centuries of ghetto life and selection it would be impossible to predict until we know more about the eyesight of the Semitic peoples generally. Meanwhile our data seem to indicate that poor sight is not the product of the immediate environment, nor likely to be substantially influenced by a change in that environment; it is rather a racial character only to be modified by selective action through many generations.

(*To be continued*)